ECOLOGICAL DYNAMICS AND HUMAN WELFARE:
a case study of population, health and nutrition in [redacted] Zimbabwe

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ABSTRACT

ECOLOGICAL DYNAMICS AND HUMAN WELFARE: a case study of population, health and nutrition in Southern Zimbabwe

This thesis examines the impact of seasonal and inter-annual variations in rainfall on food supply and disease environment, and hence the biological welfare of savannah populations in southern Zimbabwe. Ecological dynamics are thought to determine the impact of rainfall, and this hypothesis is tested through the comparison of populations either side of a major ecological boundary between heavy clay rich and sandy soils.

Due to differences in soil-moisture productivity relations, and the level and form of ecological heterogeneity, the sandveld environment shows much less seasonal and inter-annual variation in agro-ecological productivity than does clayveld, and this is reflected in food supply and consumption. Child anthropometric and birth weight data from several years shows opposite seasonality, and weight-loss in a serious drought was most marked on clay-rich soils as predicted. Differences in soil-moisture relations also influence disease environment dynamics; child morbidity shows the same seasonal and inter-annual contrasts between the zones as found with nutritional status. Furthermore, infant mortality is increased following dry years on clay-rich soils whilst high rainfall leads to increased infant mortality on the sandy soils. These differences in welfare dynamics between sandveld and clayveld appear to typify conditions in other moist and dry savannah areas respectively.

Variability in grain production results from unequal access to livestock for ploughing and manure, but urban wage labour derived remittances also affect wealth. The extent and nature of socio-economic differentiation varies between ecological zones for historical reasons, and its impact on welfare (together with that of religion and maternal education) is variable and complex, operating at several levels in household and lineage. Maternal education has a marked impact on child well-being, particularly upon infant mortality. Dramatic improvements in infant mortality and declines in fertility since Independence (1980) reflect upgrading of medical services and education provision for women, indicating the limits of ecological welfare determinants.

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Seeking to acknowledge those who have assisted in a project undertaken over several years brings a warm nostalgic feeling, especially since the early stages of research do tend to be fun, and creative work always involves interacting with people.

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The Medical Research Council (UK) provided my studentship at UCL and contributed some basic fieldwork costs, and Mr Heyes of the MRC was extremely helpful. Oxfam-Zimbabwe and Enda-Zimbabwe contributed towards field expenses through paying some local salaries in development-related work, and meeting certain other needs. During the latter part of my fieldwork I was joined by Ian Scoones, with whom I lived and worked, sharing the costs of administering the development component of the research. This involved things like my borrowing money from him to buy a pair of trousers so that we could go to the Provincial capital looking tolerably smart!

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In memory of two pioneering scholars in my field who passed away shortly before I had the chance to meet them: Audrey Richards and John Rivers.

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INTRODUCTION

This thesis is framed around a field study of population, health and nutrition in a semi-arid rural area of southern Zimbabwe. A key feature of this area, and of all savannah environments, is a strong seasonality in rainfall and a great variation in rainfall from year to year. The thesis examines the impact of this rainfall variability on human welfare. It is a departure from the thrust of previous work on this issue in that the impact on rainfall variability on food supply and disease environment is considered explicitly as a function of ecological dynamics. Scientific ecology - historically constrained in Africa as the study of game parks - is used to derive somewhat counter-intuitive hypotheses about the patterns of welfare stress experienced by people operating in a marginally altered agro-ecosystem. These hypotheses are then tested using techniques developed in the nutritional, demographic and and bio-medical sciences, but rooted in a research methodology and an approach to people clearly derived from more mainline anthropology. The anthropological approach also indicated further directions for hypothesis testing about the dynamics of welfare; notably in addressing the impact of household and lineage level social and economic differentiation, and then in the changing relationship between the population and the state and its services (health, education, etc.).

The structure of the ecological approach in this thesis is a deliberate attempt to get away from the usual approaches to the ecology of nutrition and African production systems. I chose <u>not</u> to envision 'ecology' as some kind of "mysterious and complex web" including everything from the basically socio-economic to the natural environmental, and presented to the reader as little beyond tautological descriptionism. Rather, I have drawn on ecological theory to identify specific hypotheses founded on the empirically demonstrated interactions of a few key variables. General description of the environment and productive activities - essentially the natural history of the system - is drawn upon not as theory or explanation, but as empirical material either supporting, modifying or refuting hypotheses. Central to all my ecological theorising is the approach of focusing on the understanding of <u>heterogeneity</u>, <u>variability</u>, <u>process</u> and <u>dynamics</u>, rather than average state. For example, I have no interest in the situation of the 'average' person in the 'normal' year, because they do not exist. The strategies and circumstances of people are inherently and importantly variable, just as is year by year rainfall, crop production and disease. What is therefore interesting is what happens to different kinds of people in different kinds of years, and, of course, why.

Taking an 'ecological dynamics' approach to studying population, health and nutrition, does not mean that it is possible to avoid or supersede the theory and insight developed through specialist research in each of these discipline areas by demographers, human biologists, nutritionists, and other bio-medical scientists. Though recognizing that one is inevitably limited in scope, particularly in a field study at doctoral level, I have endeavoured to ground my analysis and interpretation as thoroughly as possible in the comparative and technical literature of these disciplines.

The data used in this thesis are mainly derived from an intensive study of sixty-nine households in a semi-arid area of Zvishavane District in Southern Zimbabwe. Prospective data on agricultural production, food consumption, nutritional status and morbidity were collected over several years, and combined with socio-economic material and retrospective demographic data. Demographic, and certain other data, were also obtained from other samples in the area.

African savannah populations tend to operate only marginally altered agro-ecosystems based on a combination of agro-pastoralism with gathering/ hunting (though this is often bolstered by migrant labour). Therefore the patterning of their labour inputs and food supply reflect underlying seasonal and year by year productivity dynamics; whilst these are managed and manipulated, they are not overcome and controlled. Likewise, the populations are highly vulnerable to the basic cycles and responses of the 'disease environment'. It is soils, climate and topography that are the basic determinants of the ecological dynamics that shape how food and disease environments fluctuate with seasonal and inter-annual rainfall variability. The influence of these ecological dynamics on patterns of vulnerability, can be revealed through comparison of populations living in matched sites differing fundamentally only in their ecological dynamics.'

This thesis is therefore constructed on analysis of adjacent populations with similar social and economic characteristics and an identical climate, but living on contrasting soil types. These soil differences, and the base geology and topography they are associated with, mean contrasting ecological dynamics resulting in rainfall variation imposing opposite patterns of welfare stress. The contrast between the two particular ecologies studied in this thesis is one which has become fundamental in savannah ecology in recent years (Huntley and Walker, 1982; Frost *et al.* 1986).

In one environment - sandveld - food productivity is stablised in relation to seasonal and inter-annual rainfall variation, and the period of peak nutritional and disease stress is the rainy season and the population tends to suffer in the high rainfall year. In contrast the adjacent environment - clayveld - experiencing the same rainfall, shows enhanced food productivity variation with rainfall (rather than stabilised), and the dry season and drought years are the time of peak welfare vulnerability. I make it clear that these patterns are the result of distinct, but partly mutually re-inforcing, effects of disease environment, food productivity and domestic economic processes. Given such distinct hypotheses, critical comparative analysis between these populations can be made throughout. A further test can exist through examination of a third population - those that have neatly sited themselves along the boundary between the two soil types so that they can exploit both sets of dynamics. They are predicted to show an ameliorated stress-regime, with the least seasonality and inter-annual variations. The basic predicted patterns of welfare stress on the three populations are presented in Table 1.1.

Table 1.1 Seasonal and Inter-Annual Variation in Welfare Stress: Predicted Relationships

		Sample Populations		
		Sandveld	Boundary	Clayveld
Season	Wet	*	+	-
	Dry	-	+	*
Year	Wet	*	+	-
	Dry	-	+	*

Notes to Table 1.1
*; period of high welfare stress
+; period of average welfare stress
-; period of low welfare stress

These hypotheses (cf. Table 1.1) - having been established in detail in Chapter Three, are then tested in relation to food production and consumption (Chapter Four), birthweight and nutritional status (Chapter Five), morbidity (Chapter Six), and fertility and mortality (Chapter Seven). In the course of this investigation a number of specific questions are also addressed, that help to link the material in the different chapters, and identify important relationships that are used in Chapters Eight and Nine (see below). These include: the relationship of water supply and sanitation to nutritional status, morbidity and mortality (6.3), the relationship between nutritional status and morbidity (6.4), sex differentials in welfare variables (7.4), and the effects of birth order and birth interval on mortality (7.3).

The analysis of welfare dynamics from this one area leads to the conclusion that the human welfare stress regimes of most savannahs could approximately fit one or other of the two dynamics patterns that have been identified by the ecologists (Bell, 1982; Frost *et al.* 1986). Broadly speaking the division would be between moist savannahs on at least 500/600mm plus and/or with nutrient poor soils, and the semi-arid savannahs (500mm or less and/or with highly fertile/clay rich soils. Indeed I demonstrate that this is the case for a surprising range of welfare variables through literature review. However, it should be stressed that this is certainly not an argument for ecological determinism. Nor am I suggesting the notion that despite the diversities of the production strategies of Africa's agricultural-pastoral-hunting-fishing-gathering-trading and craft-making savannah dwellers and their myriad environments and land-use systems, there are somehow just two welfare stress regimes. On the contrary, I am trying to open the way for analytical approaches that relate ecology to production system and disease environment, and use these to develop and test a whole variety of hypotheses of welfare vulnerability.

Ecological dynamics are not alone in shaping welfare vulnerability. Socio-economic differentials in birthweight, nutritional status, morbidity and mortality are examined in Chapter Eight, in relation to contrasts in the social organisation of production and variations in consumption (Chapter Four). Using this data I examine whether (and what kind of) socio-economic differentials in welfare exist, and if they can overcome the underlying ecological processes experienced by this rural society. A similar approach is then taken in analysis of historical changes in welfare (Chapter Nine), with discussion focused around examination of the near halving in Infant Mortality Rate achieved in a few years after Independence (1980), and the effects of recent contraceptive extension. Factors shaping socio-political relationships between rural societies and the state are investigated to see whether these can transform the ecological determinants of welfare dynamics.

Having established the ambitious framework of my objectives and argument, it is important to describe and defend some major caveats on the thesis.

Although Chapters Three (and the relevant parts of Chapter Four) cover the certain aspects of cropping, and Appendix One documents hunting, gathering and fishing, this is a highly inadequate treatment of the full range of the dimensions pertaining to the ecology of production systems in this area. The significance of livestock and their management in relation to ecological dynamics is little mentioned herein (but see Wilson, 1985b; 1986a and Scoones and Wilson, 1988); this is because the ecology of livestock production is the subject of Ian Scoones' doctoral dissertation, using the same population sample. The great importance of trees and woodland products is also inadequately dealt with in this thesis (see Wilson 1986a, 1987d for treatment of this subject). Although Appendix Two traces the basic historical dynamics behind the changing production system, it has not been possible to integrate this into the central analysis of the patterning of welfare stress, though some salient historical changes in the timing and intensity of welfare stress are traced in Chapter Nine, Section 9.3. Furthermore, the short Appendix Two tries to be a general overview; yet analysis of a single minor topic (trees in agricultural land), illustrates how each element of agro-ecosystem change requires intensive historical analysis (Wilson, 1989a). Processes of agro-ecological change and 'degradation' are also hardly treated in Appendix Two, and are incompletely considered in Appendix One and Chapter Three. The impact of such processes on welfare change is basically ignored by the main body of the analysis, including in Chapter Nine on historical changes in welfare. This is despite the major way in which they are affecting these production systems (eg. the effect of soil erosion upon clayveld; Wilson, 1989b). This approach is taken partly in order to retain clarity and to control length, but also because at the current time in semi-arid Africa socio-economic and political change appears to have much larger effects than ecological change/degradation (cf. Caldwell, 1984).

Detailed data for three years was collected on the actual processes of agricultural production, including inputs (eg. manure), ploughing and weeding timeliness, and labour use (but this was not measured quantitatively). The objective of this data collection was to identify the yield determinants of different production strategies at different times, in the context of the social organisation of production to enable concrete linkage between the household and ecological variables to be drawn. However, the magnitude of this analytical task and the lack of thesis space, have meant that this was never carried through. The reader therefore has to accept my qualitative interpretations of the reasons for the production differentials observed in Chapter Four, and how this can be related to welfare variables in Chapter Eight.

Understanding the social/environmental relations of these populations also requires analysis of the social and ideological construction of indigenous ecological theory and land use systems, and their historical transformations. This was considered beyond the needs of this particular thesis, but should not be ignored as such processes have concrete ecological and economic consequences (Wilson, 1986b and 1989a, and Mukamuri, 1987, 1989).

Conscious of my ignorance of domestic processes in rural Zimbabwe, I collected systematic material on home layout, material culture, food processing, recipes and cooking processes, and the organisation of household tasks. Again these investigations have influenced my analysis, but have not been as fully integrated as they should be if the work was to be an accurate portrayal of rural southern Shona life in relation to child welfare.

The biological variables presented (eg. disease categories) have been deliberately kept at a superficial level of abstraction and analysis to avoid disguising the fact that they were obtained by rudimentary field methods, and often through maternal recall. Clearly detailed physiological and medical investigation of the phenomena discussed in this report is highly desirable if somewhat unlikely. However, I submit that it is still meaningful to talk generally about nutritional stress, elevated morbidity, etc., without such research; so long as one is aware of the data realities. As far as possible I have used literature review to justify the technical basis to my arguments. I should note, though, that I have virtually ignored the micro-nutrient issue,[2] and the incidence of oedema,[3] as both seemed unimportant at the time.

Energetics is a major omission from the study, especially given my interest in seasonality in the savannah.[4] I attempt to discuss seasonal changes in nutritional status on the basis of only food intake data almost as if there is no such concept as energy-balance. In practice I have had to rely on literature review, and general observation, to give consideration to the effects of changing work levels. Prior to initiating field work I came to the decision that measuring energy expenditures would be too great an undertaking in combination with my other work.

A central consideration given my research objectives was that quantitative data was required for rigorous hypothesis testing, but that this type of data was never valuable beyond its actual accuracy and the interpretive framework for its analysis. Accuracy and sound interpretation require a first hand field knowledge of all the individuals 'studied' and their lives (in social, economic and biological aspects). This inevitably means that samples tend to be small. This is further compounded by the exploratory and deductive method of field research and subsequent analysis, which meant that I did not always know what data was needed at a particular time from particular people and so the data are sometimes rather patchy. I now proceed to the General Methods Chapter.

CHAPTER TWO

GENERAL METHODS

Introduction

> 'If a fish comes out of water and says "the crocodile has one eye", who has been there with him?' (Ekwensi, 1962:45).

There is a major problem confronting the investigator of peoples and events far from the scientific metropole. This is how to create and convey sufficiently transparent and objective methodologies to provide the reader with the material critically to appraise the work and its conclusions. In the words of the 'proverb' of Ekwensi quoted above, the descriptions by the fish of life underwater can only be believed or disbelieved, but not challenged or improved on the basis of contrary data or experience. Since a study of the kind I report in this thesis has not previously been undertaken in Zimbabwe or a neighbouring country, how can I approach convincing myself and others that my data, let alone my conclusions, are correct, and make more meaningful any debate about my results.

I have endeavoured to 'control' for my own biases in method, observation and interpretation in four basic ways.

(1) I somewhat institutionalised methods for critical contribution by those with first hand knowledge of the area. I regularly discussed my interpretations of events and processes with local people and research assistants. University of Zimbabwe under-graduates were commissioned to do comparability studies which could be checked against my own accounts. Local agricultural and health staff were informed from time to time of my conclusions and given opportunity to comment on them. A paper was prepared for critical discussion by the District Health Team in January, 1988. I enabled access to the area by several other outsider researchers, some of whom directly tested parts of my data and interpretations. Finally, I held a day seminar with the women in the sample to discuss the results of the basic data analysis in February 1988. Acting as facilitator for this discussion I first asked them for their predictions of the relationships, and then only later informed them of my results. This led to a more genuine debate.[1] Disagreements of fact and interpretation with local people

uncovered during research and were often followed up, with even more interesting results.

(2) I have tried to base my research on as sound an overview of the environment and society studied as possible through several years' rural residence. ChiKaranga (Shona) was gradually picked up to sufficient level to interview and lead public meetings (and, most important, to chat). Great effort was put into a practical learning of rural tasks and skills, and familiarising myself with children with whom I had previously no real contact. I also gave much time to the learning of indigenous field ecology, concepts of health and disease and patterns of social relations, and the associated folklore and ideology.[2] This background knowledge and experience constantly helped me to more realistic interpretations and understandings.

(3) I have tried to use quantitative data with maximum clarity. Several collection methods/strategies are utilized wherever possible, and collection methods and analysis procedures are detailed and critiqued (in this General Methods Chapter and in notes in Data Tables).

(4) Finally, as a case study approach yielding unusual material and conclusions I have found it necessary to give great attention to setting my results in the context of the existing empirical studies in the literature. It turned out there was an enormous amount of useful empirical material in the research archives that has been rarely utilized in applied anthropological studies of this type. Indeed it has been comparative literature that has proved central in defining the thesis and interpreting the field data.

2.1 The Initiation and Establishment of Research

Selection of the Study Area and Establishment of Research Team

Mazvihwa Communal Area which incorporates 'Bungowa' in Zvishavane District (Midlands Province) is a small area of around 518km^2. According to the 1982 census (C.S.O., 1984:25) it has a population of around 17 817, at a population density of around 34/km^2; growth rate from 1969 to 1982 was at around 3% per annum. Mototi Ward is a little more densely populated than the area as a whole (42 persons/km^2). It is divided into four 'wards', which are the basic administrative structures in current Zimbabwe. The bulk of the research reported in this thesis was conducted in the Mototi Ward, in which I lived during the fieldwork. Each ward is divided into around six administrative 'villages' organised into Village Development Committees (VIDCOs). Settlement is not nucleated, however, and the Vidcos consist of a hundred homes not specifically related to social or geographical features. Under the state's land-use planning arrangement promulgated since the 1930s, and imposed in the study area during the early 1960s, the population lives in straight lines along the boundary of demarcated arable and grazing lands.

Mazvihwa is an area of low and very variable rainfall (mean c.450mm/500mm annum). It is classified as Natural Region Five by the national agro-ecological survey of Zimbabwe: that is it is considered the land of poorest economic potential. Commercial farmers are advised to use it only for raising livestock (although recently, managed game has become significant in some areas: Child, 1989), but African populations in this zone are largely agro-pastoral and remittance-income based, though wild resources are also important. The altitude varies from around 800m to 1000m, that is it lies on the lower fringe of the Middle Veld. It lies around 20° 25' South and 30° 15' East, and so experiences a cold and a hot dry season as well as a single hot rainy season.

The area of Mazvihwa under study can be divided into two ecological zones: an area of clay-rich red loam soils supporting 'mopane' and 'acacia' woodland, and an area of broken granite hills and sandy soils supporting dry 'miombo' woodlands. This ecological contrast is the basis for the thesis, and is discussed in more detail in Chapter Three.

To some extent the research area was chosen by historical accident. When I taught at nearby Dadaya Secondary School (1980-1), Mazvihwa was one of the areas I had enjoyed visiting with my students. During the initial exploratory research I found it extremely attractive partly because it was so ecologically and socially marginal. For this reason it must be emphasised that this study does not seek to be typical of general conditions in Zimbabwe. Nevertheless, the case study may be fairly representative of the heavily populated marginal regions in the southern part of the country where about thirty percent of the country's population dwell.[3]

The fact that the study area was divided into two distinct ecological zones well worthy of study was discovered from local people only through actual fieldwork. It was only later that this was related to the emerging scientific ecological literature on the contrasts in dynamics between these zones (see Chapter Three). Therefore it was this local understanding that led me to structure the investigation around the comparison of the two populations.

Initially there were problems of research acceptance due to suspicion, and a sense that I was basically too ignorant of rural life to collect meaningful material. Nevertheless, good relations were eventually established with the support of my classificatory father, C.G. Mukamuri, with whom I lived throughout the research.

As the field study ran over three years it was also essential to maintain local peoples' support for the research. Many found the qualitative research stimulating and interesting, but the systematic quantitative monitoring was often felt to be rather boring and prying, and therefore had to be kept to a minimum. As far as possible the research process was humanised to overcome this, through general involvement in the work tasks at hand and the general social activities and through conversation and humour. There was much friendship, and the research process was often fun for all concerned.[4] Rapport became good enough for people to question freely the form and purpose of the interviews. This helped us keep ethical and political concerns in view.

A popular pressure for 'action' grew out of research conclusions developed through participatory meetings alongside the individual and small group research. This was responded to by the initiation of water supply and wetland management project work with Z. Phiri-Maseko, activities which were later institutionalised (together with Ian Scoones) with support from Oxfam and some other donors. Later B.M. Chakavanda, B.B. Mukamuri, I.C. Scoones and myself launched indigenous woodland management initiatives in support of community demands, with the subsequent help of the Forestry Commission and an NGO, ENDA-Zimbabwe. These programmes, and a number of other smaller projects and activities, convinced local people that the research process was not being entirely exploitative and so enabled data collection to continue.[5]

Local people had never really entirely accepted my argument that research would contribute to development. As far as they were concerned it was their lack of finance and authority that constrained development, and this was a result of local and national political economy rather than a lack of 'knowledge' on the part of the state or themselves.[6] Recognizing this, but perhaps still rather naive, my intention was to undertake research in such a manner as to promote the transformation of these constraining relationships; that is to use an empowering research process. At one stage it certainly seemed that people would become able to undertake their own 'research' and use this to design and implement their own projects.[7] Ultimately, however, the locals initial pessimistic view turned out to be largely and painfully correct. Though I was able to attract some finance and identify and analyse faults in externally imposed policies, I could not enable local people to gain the power to implement their own programmes, except in a very minor way. Yet I know that many of the local people involved still saw the action research exercize as a valid and legitimate endeavour.[8]

It should be stressed, however, that in both the research and development activities, local attitudes and what kind of issues and data were presented became bound up in underlying lineage disputes within the area. Efforts were therefore made to prevent us being too identified with the lineage and local political interests of my principal patrons and the research assistants/co-workers.

The initial stage of field work (September 1985-April 1986, for which I was in the field only for September until December), was dedicated to introducing myself and to making a general and rounded qualitative investigation of the environment, production system, and population. The purpose was to use this to better frame and direct subsequent quantitative investigations.[9]

The second stage was to establish systematic monthly sampling of a defined sample (May 1986 to August 1988). To do this a full time local support was required, and two assistants were trained 'on-the-job'. 100% supervision was provided in the early months dwindling to around 30% at the end of my main field work, and finally 'unsupervised' work after my departure. It was thought important to involve them as closely as possible in the intellectual side of the research process, as well as simply data collection.[10] However, I tried to avoid a spirit of direct hypothesis testing with quantitatve data by them (or myself) in the field, so as to minimize recording bias. This was actually helped by my ignorance of most of what would become the main specific hypotheses in the thesis until well into the analysis. Critical objectivity was stressed in regard to data collection. Abraham Mawere became my principal research assistant at this time, working with several others.[11]

Once this second stage was well established and we became more competent, it proved possible to conduct additional research investigations around related topics. These included short projects by under-graduate University students during their vacations, one of which was used to write a dissertation (Mukamuri, 1987). Short trips were made to adjacent areas (Chivi, Zaka, Runde and Matibi) for comparability analyses. Public meetings within the study area were increasingly utilised for development-orientated research in 1987, several of these were held jointly with Ian Scoones. The development activities described above, and the staff involved in this, B.M. Chakavanda and Z. Phiri-Maseko, contributed greatly to the 'research-team' atmosphere and to the morale of 'pure researchers' working in a situation where people demanded change. Also important was the fact that initially the research team all stayed at the home of C.G. Mukamuri at Mototi. Motorcycles and pedalcycles were shared for transport.

Other outsider researchers were invited to work in the area using the sample and/or the general accumulated data base, to improve the reliability of the interpretations being made.[12]

Definition and Operationalisation of Questions

My research agenda was developed largely through the process that I later realized to be the 'extended case study method' (Gluckman, 1967; E. Marx, 1989). Theory was developed in tandem with on-going critical observation and data collection in the field, and then again subsequently during the data analysis. Although it is obvious that what I 'saw' and how I recorded it was ultimately not independent of my own theoretical stance, I tried to structure my time and thinking to allow as diverse an approach to my material as possible. I took copious contextualising notes, and encouraged this of my research assistants also.[13] This enabled the transformation of the initial research agenda in the light of new issues thrown up by field realities and preliminary analysis.

Creation of Sample

I created a sample through unorthodox means, and therefore need to describe and justify this at some length. I required a population sample that I could rely on for long term compliance, and who would be prepared to give me accurate and sensitive information. I wanted the sample to be small enough to enable me to achieve my objective of quantitative data without compromise of accuracy and qualitative interpretation, and initially estimated this to be about forty households.

At the time of the start of the quantitative data collection phase my principal research goal was to demonstrate the way that social and economic organisation functioned in interaction with the differing ecologies of the production system to determine household welfare outcomes. The initial research had shown that the units of social and economic organisation, and of domestic management, were the co-operative household cluster (usually a shallow patrilineage), the residential household and the individual wife/kitchen. In order to capture all these levels, it was necessary to select as units not households but household clusters. These clusters were sometimes of people of comparable (low) socio-economic status and essentially co-operative in form, but were more usually hierarchical, and based upon patronage. Cattle-access was the focus of these clusters, as cattle were ultimately the basic means of production.

Clusters could not easily be chosen randomly: even to define them required fairly intense research. Fortunately because clusters tended to be socially inclusive (ie. of rich and poor, male and female, young and old, etc.) even a non-random sampling of clusters would be expected to result in little bias at individual household and kitchen level. Furthermore, it was possible to select clusters from different areas, and to deliberately strive to be representative (eg. of religious groups, different lineages, etc.). It was also deemed essential that a few 'individual' households that were not tightly integrated with others be included. These totally isolated households were uncommon and tended to be either very rich or very poor.

A process of selection then occurred on the basis of existing social contacts, especially those of my patron (C.G. Mukamuri), who well understood my desire to be representative. In practise, the follow-up field visits tended to identify slightly different configurations of households than originally intended. This came out of the identification of the changing webs of social and economic links between households. In a number of places we made more than one cluster, and included most of the homes at the site.

Initially about half the homes selected for the sample were in the clayveld ecological zone and about half on the edge of the sandveld (which I later termed boundary). Only one was in the sandveld 'proper'. The adjustment made to this sample is discussed further below.

It must be stressed that this method of selection was non-random, and must be treated as such. The approach taken in this thesis is to compare sub-groups of this sample by defined character differences. Therefore the fact that the sample was diverse and approximately representative is sufficient. As it turns out, comparisons of field and stock ownership with local official's censuses and the population, aerial photograph and land area figures for the area, do suggest that the mean data on household size, field area and stock holding for the sample is indeed 'average' for the population. But, as will be described in detail below, several biases have crept into the sampling process.

During the definition of the sample there was considerable pressure to include more homes than originally intended. This was both from households loosely associated with those who had been selected, and from villages that had been 'left out'. About a dozen extra households were included in association with existing clusters: most of these were poorer and smaller than average, and many were women-headed. This perhaps redressed the balance due to a number of relatively wealthy contacts initially selected. One further wealthy household was also included, as a family member had joined the research team and this would enable good data access. It was at this time that two households refused to join the sample. One was a poor individual household, and a replacement was found. The other was the (agricultural) home of a village-teacher and it had been hoped to have some households where the person employed lived locally. As it turned out this was hardly a problem as four of the 67 households ended up with permanent salaried research assistants as members! (Though this introduced its own biases.) Two extra clusters were also incorporated into the sample early on. One village approached us privately, and we agreed to include them, as we had nobody from this area. There were a number of notably wealthy households in this group, as well as some poor ones. A second cluster was recommended to us by the Councillor, Mr Bwoni. He was concerned that too many of our clusters were patronage-based, and so we added another poor co-operation centred cluster he recommended from his home village.

The sample of sixty seven households and seven hundred people (527 permanently present), is just over ten per cent of the population in Mototi ward.

As mentioned above, the initial sandveld cluster was later largely re-designated as 'boundary' in nature. Prior to the detailed studies of agriculture and resource use it had not been apparent that this population was neatly utilising the resources of both ecological zones. In had appeared to be 'sandveld' from the perspective of my residence in clayveld. Therefore, and on the initiative of Ian Scoones, a third cluster was added to the sample in January 1987 of sandveld households from the edge of Mototi Ward in neighbouring Murewa Ward. Unfortunately, selection in this distant community was wealth biased, with six of the seven households in the top two (of four) wealth categories, and almost all of the children under ten in the top wealth category one. (This bias also reflected the greater wealth of much of the sandveld population at that time, due to the run of low rainfall years, which I show in this thesis to impoverish clayveld populations relative to those of sandveld.) Five of the seven household heads were aged fifty to sixty years. This inadequacy of the sandveld samples (too small, wealth and age biased, and starting late), is the main structural weakness in the thesis. I have endeavoured to overcome it through three main routes. First, I have often combined boundary and sandveld populations, so as to facilitate contrast with the clayveld sample. Age and wealth biases are fortunately complementary between these populations. Second, I have used data from other sandveld populations in the region to supplement the small core sample. Third, I have confined some of the analysis of differentiation to the clayveld (and, to a lesser extent, boundary) populations.

2.2 Data Collection

Introduction

A monthly round was used for data collection from the quantitative sample, though each form of data was collected at a different time interval.

The interviews were undertaken in a directed but friendly and relaxed manner. New questions were preceeded by a brief introduction of why this particular information was needed. If the interviewee was unwilling to answer we discussed the reasons for the question with them, and they almost always ended up agreeing to answer the questions. Care was taken to address questions to those with the knowledge and authority to actually answer. Where men were present, it was usually seen as appropriate to ask them about agriculture, though they often called for assistance with questions from their womenfolk. The women actually responsible for each child was involved in the discussions of health and nutrition. Re-visits were generally made to locate the right person for interview, rather than using other family members or other proxies. Whilst women were initially used to interview women, it ironically turned out that for ordinary data collection the male research assistants were more effective.[14]

There is no particular compunction to tell the truth in Shona society, and indeed, giving an exaggeration or 'lie' is often seen as more interesting/ sporting than the truth, especially if it makes a stimulating point. Furthermore, many people felt that they had good reason to misrepresent themselves to the research assistants, and sometimes to me and the outside world. Therefore we had to be very careful in converting answers into data. Direct critical observation and involvement, accumulated first-hand knowledge, and the asking of other family members and neighbours was important. Fortunately this is a less significant problem with women (especially young women), than with men, and women provided the bulk of the data used in this thesis. Since there is no shame in lying or being caught lying it was relatively easy to avoid too problematic an encounter: people would just laugh or take no notice if you pointed out to them that you knew they had, for example, no donkeys, or still a second granary full of grain.

Demographic parameters

The first stage in the quantitative study was to identify all of the members of the households in the sample, and their biological/social relationship to eachother, and to the other members of the household cluster. This information was used to prepare family trees that could be used for further interview work. Dates of birth were established for those under twenty years of age, years being generally known in this population (though some discussion and cross-referencing was sometimes necessary). Older people were divided into ten year age brackets. Each individual was classified as 'present', 'oscillating' or 'absent' according to their behaviour during each year of the study. During monitoring (and on a monthly basis) the arrival and departure of additional people was recorded, together with births and deaths.

Each individual was ascribed to a 'kitchen', as well as to a household. 'Kitchens' function as the food consumption units, and are the locus of economic organisation alongside households. Where there are more than one kitchen in a household, the senior man or men is a member of all kitchens. Food is sent to these men on rotation in some homes, and in others all kitchens send a plate of food each meal (except, perhaps, if a particular woman is menstruating).

During the period of monitoring there were cases of the (expected) processes of kitchen and household fission; alongside problems of unresolved household definition. In these cases households were amalgamated, as their economies and domestic organisation continued to be interwoven, and this represented less data loss.

Ecological parameters

Ecological parameters were largely investigated in a qualitative fashion, principally through tapping indigenous ecological knowledge. Interpretation was strengthened through use of the empirical and theoretical insights of a considerable body of scientific ecological research elsewhere in Zimbabwe and the region. This data is used in Chapter Three to present the ecological justification for the contrasting welfare dynamics examined in this thesis.

Rainfall data was obtained for local stations from the Meteorological Department. Two adjacent ranches also provided private data. Though there were a number of nearby collection sites, there were no records being collected in the Mazvihwa Communal Land at the time of research. Therefore the Meteorological Department provided the equipment for three rain gauges which I established mid 1986 at three pivotal points in my study area. The data is generously recorded by clinic staff at Gudo and Mutambe, and at Mototi it is now recorded by members of the household in which I lived.

The mapping of woodland types in most of the area was undertaken by Bryn Higgs in 1986 (Higgs, 1987). Higgs classified woodlands on the basis of indigenous theory confirmed by quadrat analysis. He then mapped them through transects and by observation from kopje hill tops, tracing onto aerial photographs, with the help of Oliver Chikamba and B.M. Chakavanda. Since Higgs established the relationships between soil types and land-use, the mapping also served to confirm the distribution of soil-based ecological zones used in this study.

1:6500 aerial photographs were obtained for the area that had been taken in 1985.[15] It was therefore possible to very specifically observe the relationship between land-use and environment during research.

During early 1988 several soil pits were dug to 1m deep in each of the main soil types by Jacob Zhou. A 1m soil auger provided by the Department of Biology, University of Zimbabwe, was used to take further samples to supplement the pits. Profile descriptions were made, including on the degree of water penetration in recent rain events. In the pits the number and type/species of roots in the different horizons was recorded, confirming differences in vegetation ecology.

The number and species of pieces of wood in firewood stores was assessed by B.M. Chakavanda and P. Ndumo in the pre-rains period in 1986 and 1987. I use this data in Chapter Three to illustrate contrasts in environmental use between sandveld, clayveld and boundary populations.

Phenologies of fruiting trees were obtained through discussion and checked by observation and eating over the years' of residence. Bud-burst of trees was observed and recorded as it occurred, as were changes in the moisture content of the natural wetlands (dambos).

Trees left standing in agricultural land were investigated with a suite of qualitative and quantitative methods. Densities of different species were obtained through a combination of aerial photographic analysis and direct observation. Soils and yields beneath and away from the trees were sampled and analysed with the help of the Department of Biological Sciences at the University of Zimbabwe. Nine soil samples were taken at random distances on transects from each of twelve trees of three species (*Parinari curatellifolia*, *Ficus sur* and *F. stuhlmanii*). Each of the samples was obtained from soil mixed and sieved from three samples taken from within $1m^2$, at a depth of 15cms. Organic matter, soil moisture, pH, nitrate and phosphorous were obtained for the soil samples; but the precise methods of analysis and full results have not been released to me. These trees have important ecological implications production dynamics in sandveld (Chapter Three).

Assets and livestock holdings

Basic household assets were enumerated during the first months of visit, using a combination of direct observation, and directed and undirected questioning. Farming equipment (ploughs, cultivators and harrows), scotch carts, stock holdings, and the form of household roofing were the data recorded here. The data for cattle and goat holdings used in this study are derived from subsequent monitoring of the sample by Ian Scoones, whilst donkey, chicken and sheep data are used from my initial survey. Obtaining accurate figures for livestock holdings was made complex by frequent reluctance of people to divulge full figures, and by the complexity of ownership relations and terms (cf. Scoones and Wilson, 1988).

Arable land area was determined by visiting the fields and tracing the boundaries using the 1985 aerial photograph (scale 1:6500), taking account of any recent changes.

Agricultural production

The overall method of monitoring of agricultural activity and production was quite complex, but as I use only total cereal output in this thesis I will discuss only how those figures were obtained. Output of each crop was determined from recall for the 1984-5 harvest, and by prospective monitoring for the 1985-6 and 1986-7 harvests. (Further data for the 1987-8 year are not analysed in this thesis.) As farmers typically publicly count out their sacks of grain in good rainfall years, overall yields are fairly well known. It was considerably more difficult to determine harvests in the years of low yield, than in good years. This was because much harvesting was done piecemeal from the fields rather than done and measured together, and, furthermore, farmers were generally anxious to stress the poverty of the season. In the poor harvest years women gave even better data (relative to men) than they did in the good years.

Unfortunately, though all but one of the households measured their grain in sacks prior to storage, the size of a bag (sack) varies. The 'official' bag or sack of cereals is 90kg, and contains five 'buckets' of grain. The 'local' sack or bag tends to contain six or seven buckets, though some people do use the official bag. In this study a sack was taken as 6½ buckets (118.3kg) unless we were informed otherwise at the time of data collection. In some cases the harvest had to be calculated from the numbers of cart loads of unthreshed grain brought from the fields, using locally calculated conversion ratios.

Food consumption

Food consumption was investigated in several ways, attempting to get past normative statements, but falling short of full and detailed scientific investigation, which would have absorbed more time than available and been too intrusive.

Diet was monitored for a full week on two occasions during the year of study in a sub-sample of households/kitchens. These were intended to be dry season and rainy season, but the rainy season monitoring (late Februrary 1987) turned out to be a little late as the rains finished very early in 1987. Only boundary and clayveld households were included, as the study was initiated early in the research, prior to the proper establishment of the sandveld sample. A literate member recorded everything that was eaten and drunk both at meals, and outside of meal times, during a full week. Presence and absence of household members was also recorded, alongside some qualitative information on food sources, etc. Special forms were prepared to enable enumerators to record effectively. The enumerators were mainly school girls, were keen, and 'trained' and supported, so there was relatively little default. A detailed critique of this kind of method for determining food intake is provided in the appropriate section of the thesis (Chapter Four, Section 4.3).

On another occasion women were asked to list the important side-dish "relish" plants consumed. Qualitative interviews on 'bush-foods', were backed up by direct observation, and a recall survey I designed on certain woodland-related foods (caterpillars, honey, fungi and cicadas) undertaken in early 1988 by Florence Shumba, financed by Enda-Zimbabwe.

Cereal consumption estimates were based on three methods. Women were asked how much cereal they took to the grinding mill per month, this being the major way in which they produce flour. Second, the number of pots of sadza cereal porridge cooked per day over a week (and the size of those pots and hence their cereal content) was measured in the diet survey. Third, the level of consumption was estimated indirectly from knowledge of harvest output and purchases, as against levels in storage granaries, beer production, weevil losses and (hence) consumption. Cereal consumption was also estimated by assuming that *per capita* calorific intake conformed to FAO/WHO guidelines, and that cereals contributed 60-75% of the energy intake.

Beer production was estimated from recall of the number of brews, and the average number of buckets used per brew. This was important for understanding what happened to cereal production at a household level (Chapter Four).

Anthropometric status and birthweight

I assessed anthropometric status using age, weight and height for children between three months and ten years old. Assessments were made at two monthly intervals in 1986-7; households were generally visited at the same stage in each month as part of a strict rotation. The later assessments (1987-8) were made less regularly.

Age was determined as described in the section on 'demographic parameters' above. Where it was not established for certain to nearest month (ie. with documentary or similar quality evidence) no age based anthropometric assessments were made.

Weight was assessed using 25kg and 100kg Salter Spring Balances, donated by the company. Most of the children were under 25kg, and so were assessed to the nearest 100g, but those over 25kg were assessed to the nearest 0.5kg. The balance was repeatedly checked. Children were weighed with minimal clothing, and 100g was added to the weight to compensate for clothing. Babies were more problematic, as it was often not easy to ask that the baby be undressed entirely, including nappies. Little use was ultimately made of weights under two years of age. Children too young to hold on to the hook directly were weighed from a locally made cloth bag, with the spring-balance adjusted to zero.

Heights were taken using a wide locally constructed heightboard (150cms) with a large foot-piece set at exactly 90°, with one centimetre intervals marked across the board. Children stood erect with their legs together and heels, buttocks, shoulders and back of head touching the board. The head was held such that it looked straight forward. Unfortunately the eyes and top of the ears were not systematically aligned to ensure head straightness. The height was then read using a very large set square set on the top of the head. Measures were taken to the nearest 0.1cms insofar as this could be judged by eye from the 1 cm intervals marked on the boards. Children under two years were not 'heighted', as this required that they be measured horizontally for length, which was unpopular with parents. There may have been insufficient rigour in height measures, but they were virtually all taken by Abraham Mawere and myself, and this may help to maintain comparability.

Zimbabwean parents are accustomed to the weighing of children and welcomed the assessments. Sweets were sometimes given out during anthropometric assessment, and the measurement integrated with general discussion and activity, so it was also generally popular with the children. This reduced the incidence of escape!

Unfortunately the nutritional measurements only allow a rigorous analysis of seasonality for 1986-7. It was deemed important to compare this pattern with other years. Most of the children in the study sample possessed Road-to-Health cards, upon which weights are recorded at clinics and nutrition meetings. These records go back to the early 1980s, but the bulk of the records are from 1983 to 1986. These measurements were extracted from the cards and converted into weight-for-age assessments.

A cross-sectional anthropometric survey was made in the neighbouring sandveld Vidco of Mutambe in Februrary 1988, as part of the comparability study to strengthen the understanding of sandveld. Weight, height and age (the latter, as far as was feasible in a cross-sectional survey) were recorded, as described above.[16]

Primary School children (aged seven to about sixteen) were assessed at three time intervals (July 1986, October 1986 and January 1987), with the encouragement of school staff. Weight and height were taken, with the assistance of the regular research team, using the same method as described above, except that 200g was deducted from boys and 500g from girls for minimal clothing. Ages are not easily determined in schools for legal reasons of restrictions on retaking classes and examinations.

Birthweight data is written at birth on Road to Health Cards when the child is born in a clinic or hospital. Records were taken to the nearest 100g, or occasionally 50g, and appear accurate. Only singleton births were used. One birthweight was described as pre-term by the mother, but was still included. Clinic or hospital births may be biased in some way, but it should be stressed that it is not unusual to give birth at a clinic in this population. There was no bias in the numbers of birthweight records for mothers of different wealth in this sample, and little relationship between wealth and birthweight; however illiterate women appeared to give birth in clinics less frequently than others (Chapter Eight).

Morbidity

Mothers or guardians were asked each second month of visit whether the children under ten years of age had been ill (-**gwara**) during the past week. As the question investigated the presence of morbidity during a defined period prior to interview it is neither incidence or prevalence in form; however, such prevalence-incidence data is commonly used in studies of this kind even though it makes comparision of 'morbidity rates' between studies problematic.[17] Mothers were also asked to determine the seriousness of the complaint, and to describe the action that they had taken in regard to the morbidity.

Mothers experienced little difficulty with the morbidity question, especially in subsequent rounds, except in certain cases of a child recovering around the time of the start of the week. Mothers were allowed to use any indigenous term they felt appropriate. The initial 'disease classifications' prepared with a medical student, A. Irene Masanga (Wilson, 1986), and a little subsequent work, proved adequate to convert these into broad morbidity categories. It should be stressed that these are not diseases as such but things like 'diarrhoea', 'headache', and 'sore eyes'. Sometimes multiple symptoms were presented. either together or sequentially in the previous week. The basic child complaints (gastro-enteritis, ear-nose-throat [referred to as ENT], and ocular infections) dominated morbidity. It was decided to include all morbidity, including cases of sores and wounds, as though they might superficially be seen as independent of season, inter-annual or wealth processes, the rate of healing will be affected by differential hygiene, general health, and physiological stress. Generally speaking the child was present during the interview, and this tended to increase the accuracy of reporting. Direct observation of the child rarely seemed necessary, and anyway I did not have the requisite technical skills. Diagnoses were available for children who had visited clinics.

The only study that has contrasted reported morbidity with clinical examination in rural Africa was apparently a large survey in Ghana (Belcher *et al.* 1976). This study found that (not surprisingly) straightforward dysfunctional complaints (eg. blindness and diarrhoea) showed much greater comparability than things like clinically diagnosed anaemia and intestinal parasites (1976:756). Hence the focus in this study on directly experienced morbidity. Although the authors are pessimistic about relying on reported health, they do note that highest reporting accuracy was achieved by mothers interviewed about their children (1976:755-6), as was done in my own study.

As far as the mothers were concerned 'morbidity' was understood as basically a functional impairment. Yet it was inevitably conceived in a context of what could be labelled and what was defined in a neat temporal framework. Certain not very specific chronic complaints were presumably under-recorded, for example there were no records of the actually quite common, pin worm (*Enterobius vermicularis*) that children experienced as a chronic anal irritation. Differences in experience, attitude and expectations of women will affect their identification of morbidity in their children. However, it is not thought that there are systematic differences between population sub-sectors, though this (of course) has not been proven. People live in household clusters, and child care arrangements involve women coming into intimate contact with a large number of other children first hand, and this may have a stabilising effect on what different women consider to be 'illness'.

Morbidity levels were also obtained for an adjacent area of sandveld (Mutambe Vidco) using a single round survey in Februrary 1988. Women were asked in the same manner as in Mototi, with their children present. Although the method would appear likely to produce less accurate data the levels of morbidity for major infections proved very similar to other wet season sandveld levels.

Two clinics provided attendance records (monthly totals for different disease categories) for 1987. Morbidity for under and over fives was separated in these records. Obviously these data represent the interaction between levels of morbidity and desire and/or ability to visit the clinic.

Fertility and mortality

Fertility and mortality were assessed retrospectively, as the sample size was too small to obtain good figures prospectively over a period of only two years. A situation of domestic flux, whereby children frequently grow up in a whole series of homes, meant that retrospective household-based assessments were not considered reliable.[18] In order to be able to strictly monitor all children it was decided to ask mothers about their offspring. Offspring who had largely lived outside the area were listed, but subsequently excluded from analysis.

Each woman in the sample gave a full fertility history, and information on the survival/mortality of each child. Only a few women had to be left out: some who were much absent, and several old women who were generally uncooperative. Dates were assigned in discussion with the women, using local events where necessary, as there was sometimes uncertainty. In the case of women with children born in the last twenty years we already had much of the necessary data from the demographic survey (except for mortality). These histories were checked with other family members where appropriate, and sometimes through repeated questioning. Questioning was most difficult in cases where women had lost all or very many children. Fortunately one woman who had lost all four of her recently born children did not have to be questioned as she lived with one of the research assistants who had closely observed the events. Andrea Cornwall, who used the data for these women as a baseline for a subsequent study (in 1988) did find a number of errors (or at least differences) in these histories. These especially concerned the confusion of the reporting of miscarriages, still-births and infant mortality, but in her view these errors were unlikely to lead to systematic biases (A. Cornwall, pers. comm. 1989).

Reported miscarriage and stillbirth rates (17.9 and 11.9/1000 respectively) were very low compared with stillbirth rates more accurately recorded in Eastern Kenya of 20-30/1000 (Omondi-Odhiambo *et al.* 1984:214). Potter *et al.* (1965) have produced important evidence of under-reporting bias in these two rates: in that study prospective monitoring of miscarriages produced a rate five times higher that of retrospective questioning.

2.3 Analysis of the Data

Introduction

The precise ways in which the data have been used for each analysis is laid out at the time of actual presentation, so as to make explanation immediately available for the reader. In this section of the chapter I explain the general manner in which I have processed production, nutrition, health and mortality data, and the principles upon which my interpretations are based.

The following principles have been followed in the analysis of the quantitative data:

(1) The limitations of the quantitative measures (eg. weight-for-height status, or diarrhoeal morbidity) and how little is known about their functional implications, is kept in mind in interpretation of the data, and the selection of analytical procedures.

(2) Simplicity of analysis. Most of the thesis is inevitably based on data with fairly small sample sizes and rather patchy collection. Two approaches to the analysis of this data were rejected. I decided against relying on case history description, which could have enabled me to integrate the qualitative and quantitative data quite well. This was because I felt I was in danger of story-telling, simply reinforcing my presuppositions about the causal associations between social and biological processes. I sense that at this stage in our understanding it is necessary to trace out the skeletal relationships of single (or at most two) factors, in a quantitative manner. This can act as paving the way for more disaggregated and yet integrated approaches. Such approaches are ultimately necessary as contingency is critical since the welfare outcomes of events for particular individuals and groups are the result of unique interactions of many variables and processes. A second approach I chose to avoid was the use of complex analytical procedures. This partly reflected my lack of access to and literacy with the necessary computing facilities during the key period of analysis. But I also feel there were good reasons for maintaining a simple step by step analysis. I wanted the data (warts and all) to be kept clearly in view; I did not want them submerged and lost in an analysis I was

therefore uncertain how (and how far) to interpret. I also suspected that such analyses could lead to a spurious sense of precision and comprehensivity, ultimately unwarranted, but difficult to question once obtained.

(3) Hypothesis testing on the systematic thesis theme is pursued. Statistical analysis is thus single-tailed. No correction factors are used in binomial and χ^2 analysis to compensate for small sample sizes.

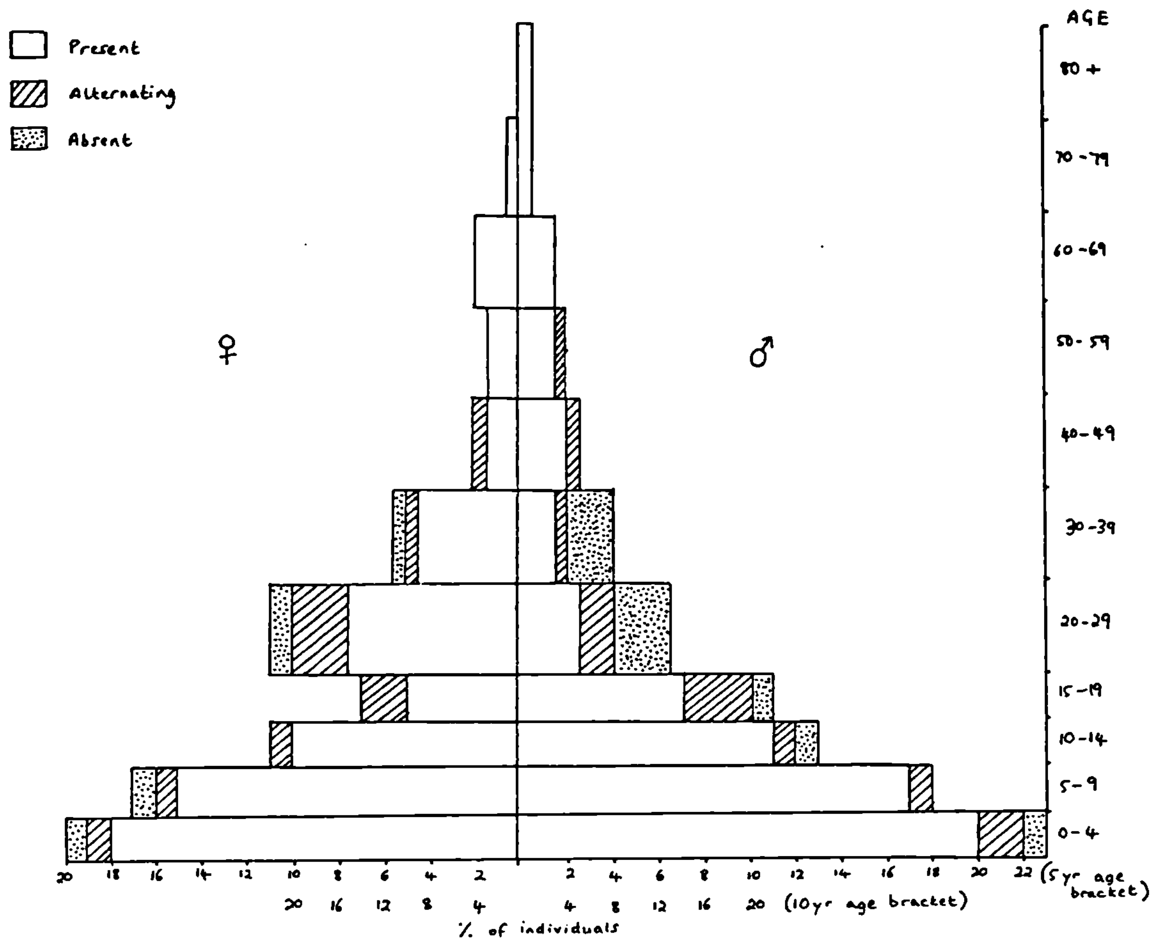
4) Step by step interpretation is aimed at. A series of different kinds of data are analysed to construct the argument.There is then critical interpretation with discussion of the wider argument and hypotheses in the light of literature review.

Demographics

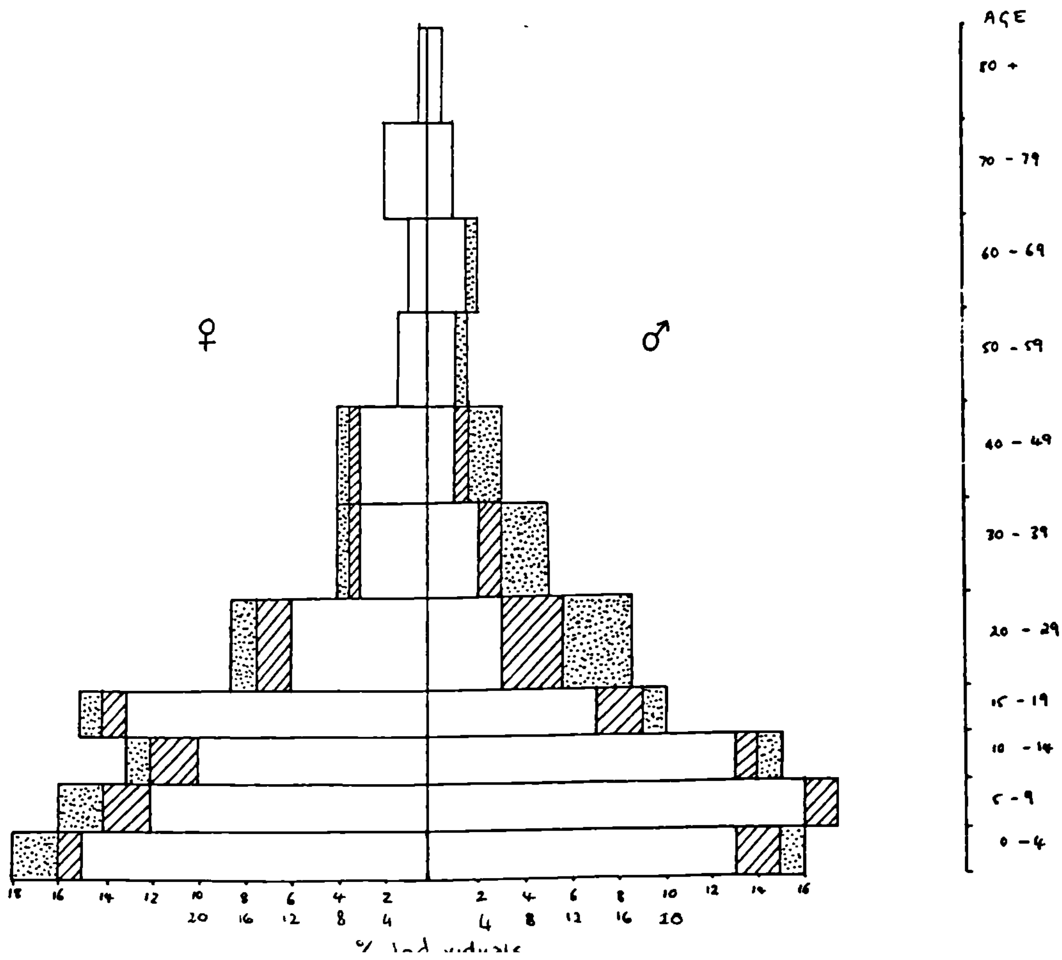
Population pyramids were constructed for the clayveld zone versus the combined sandveld and boundary zones. (The latter were combined as this was frequently required by analysis.) The pyramid is presented as Figure 2.3.1. Each individual was coded according to his or her age and sex and an estimate of their degree of residence, for each of the three years of study. I needed methods to produce data on household size and composition in a simple framework for comparative analysis. To do this, people were converted into Adult Equivalent Units (AEU) according to their nutritional requirements, according to the system of Collier *et al.* 1986:71, (see Chapter Four, Table 4.1.1 for the figures used). There has been no attempt in the literature to estimate the non-food requirements of people of different age/sex, and therefore the widespread use of nutrition-based conversion schedules for consideration of all economic data should be questioned. However, as I focus upon food in this thesis, this is not such a severe limitation. There has been no attempt to calculate Adjusted Adult Equivalent Units (AAEU) to take into account economies of scale at household or kitchen level. The proponents of this technique (Collier, *et al.* 1986) fail to explain what the nutritional economies of scale are, and exactly how the other economies of scale can be determined in an objective sense, given available data, let alone how to consider the effects of inter-household relations and economies of scale.

FIG 2.3.1. POPULATION PYRAMIDS:

a) SANDVELD AND BOUNDARY POPULATION



b) CLAYVELD POPULATION



Residence status was calculated in the following manner. Virtually full-time residents were each multiplied by 1.0; those alternating between present and absent (or long stay visitors) were multiplied by 0.5; and those essentially absent, but still listed as household members, and visiting during the study, were allocated 0.1. In cases of birth and death during the year in question individuals were allocated 0.5. The extent to which these categories actually spent these proportions of time and/or resources has not been examined.

In the analysis of demographic changes through time I have used the key reference point as the year of Independence (1980). Obviously the changes brought about in the country by a change in political regime were not effected instantaneously, but occurred over several years. Nevertheless, this year seemed appropriate as a general reference standard, though occasionally year by year changes over that period have been examined. The other watershed year in the demographic material seems to have been 1950, after which mortality was considerably lower. A variety of marked socio-economic changes occurred around this time that ideally call for detailed historical investigation (cf. Chapter Nine). In the data for Mutambe, which were derived from a one-off survey, the data appear to become incomplete prior to 1960 (very few deaths are recorded, and reported fertility concurrently becomes much lower), so 1960 is taken as the starting year for this sample. Some changes in the levels and patterns of infant mortality may have occurred from the mid 1970s connected to the war and rising levels of female education, among other factors. Therefore the twenty five years of IMR data regressed against rainfall levels are for 1950-1974. There is also some use of decadenal analysis in the thesis, which is aided by the fact that the pivotal reference years all mark the start of decades.

Defining the seasons and wet and dry years

Chapter Three, Section 3.1 presents a discussion of rainfall data, whereby four seasons are established for this area:

Dec/Jan/Feb:	the rains
Mar/Apr/May:	post-harvest
Jun/Jul/Aug:	cold dry season
Sep/Oct/Nov:	hot dry season

These same season distinctions are used for all analyses, except for several considerations of the 1981-4 drought period, where the rains were very late and Jan/Feb is used as the rainy season. On some occasions the hot and cold dry seasons are combined into a single 'dry season', when the patterns appear similar and/or the amount of data is inadequate.

Although the hot and cold dry seasons are fairly predictable, the rainy season (and consequently the time of harvest) does vary quite considerably. As rainfall is also very patchy, it is not possible simply to use one or other local rainfall station to define the wet and harvest seasons for each year studied. It is also possible that more disaggregated analysis would show that there are peak periods within seasons, or freak seasonal occurrences that have marked and/or unusual impacts on welfare. For the present, however, I am working on a very simple system of rigid three monthly seasons.

The concept of wet and dry years is derived from the fact that recent decades have been marked by runs of wet years and dry years of approximately ten years length (Tyson, 1978). This is discussed in some detail in Chapter Three, Section 3.1. These runs of years can then be grouped for analysis of certain demographic variables.

Table 2.3.1: Dates and Rainfall Amounts in Runs of Wet and Dry Years

	Mean Rainfall (mm) (Zvishavane)		
	n	mean	$\sigma n-1$
Wet Periods:			
1952-9	8	688.0	190.0
1974-81	8	783.7	183.3
1985	1	806.0	-
Dry Periods:			
1960-73	14	510.1	174.5
1982-4,86-7	5	363.5	102.4

Notes to Table 2.3.1
Rainfall years in Zimbabwe run July 1st to June 30th; the calender year listed is the year in which the rainfall season closed (ie. the harvest was achieved).

I was only able to get data up to 1984 from the Meteorological Office. The figures for 1985 and 1986 are from neighbouring Texas Ranch. (Figures gratefully received from the Farm Manager, to Ian Scoones.) For 1987 the newly established Mototi station at my home was used. It should be noted that the long term mean for Zvishavane is around 580mm, whilst for Texas Ranches and Mototi it is around 500mm, and 450-500 mm respectively.

There are marked differences in mean rainfall between the wet and the dry years (Table 2.3.1). However, it should be pointed out that within runs of wetter or drier years there is quite a lot of variability in both total and (all important) rainfall distribution.

Runs of wet and dry years are a useful analytical tool because they not only represent the culmulative effects of wet and dry years, they also help reduce the effects of small errors in the dating of demographic events (where this is based upon recall).

Years were also divided into three categories: dry, 'average', and wet for some of the demographic analysis. Dry years were those with less than or equal to 450mm, 'average' years were those from 451-650mm, and wet years those with over 651mm. The rainfall data used was a mean of the two nearby stations with the longest records: Chivi and Zvishavane, which lie in different directions from the study area. (The mean rainfall for these two stations combined is 560mm; about 100mm greater than that for the study area. Although these areas are wetter, the variations in rainfall from year to year [what is being tested in this analysis] do have an approximately similar pattern.)

Identifying wealth categories

For the analyses of how wealth (economic differentiation) was reflected in food production and consumption (Chapter Four) and in welfare variables: mortality, morbidity and anthropometric status, (Chapter Eight), it was necessary to categorise households. This information was required by both Ian Scoones and myself. Enough economic data existed for us to do this on the basis of choosing and assigning weight to particular variables. But we were concerned to enable wealth-status to reflect what local people saw as the significant economic factors. Dr C. Jackson therefore recommended that group ranking methods be used so that the people could assign rank to the members of their own community. On the initiative of Ian Scoones, we decided on a small male and a female focus group to do this ranking, with the local research team comprising a third group. The exercise was then undertaken in early 1988 during a return visit by Ian Scoones, with the help of A. Mawere and B.B. Mukamuri and others. Good correspondence was obtained between the ranks allocated by the different groups, and strong association was found between wealth rank and certain economic attributes, especially cattle ownership (Scoones, 1988c). Discussions of the concept of wealth held at the time also threw light on the nature of differentiation (Scoones, 1988c).

Since six households (9%) were omitted (forgotten) in this ranking exercise, I asked research assistant Abraham Mawere to allocate ranks to the households himself. The ranks for these households were then communicated to Ian Scoones, so that a common system could be utilized for analysis.

There are several problems with the use of wealth ranks (categories) for the differentiation analysis:

(1) Wealth ranks were assigned on wealth rather than income or expenditure. The problem with this was put in a nutshell by those women who told me that the reason why there was no relationship between wealth and nutritional status is that the wealthy accumulate assets by making women and children work and denying them consumption. Wealth is only one dimension to economic differentiation. (For an examination of some empirical data on the relationship between assets, food production and food consumption, see Chapter Four.)

(2) Household-level attributes were demanded, and it was households that were allocated wealth ranks. This ignored both extra-household dimensions (the importance of differential resource access - such as draught power - from other households in the clusters), on the one hand, and intra-household differences in economic management and resource access, on the other. Income and property are essentially managed privately on an individual level, and dispensed both within and outside of the 'household'. The only clear joint consumpion (and even here they may be privileges) is of food, and this is undertaken at kitchen level, not household level. Though most households have only one kitchen (86%), there were 1.3 kitchens/household in the overall sample, and the proportion of people (as Adult Equivalent Units) living in multi-kitchen households is much greater: 27%. This is because households

with more than one kitchen are more than twice as large on average as those with only one ($p<0.0005$).

(3) Household ranks were allocated on composite factors by the people involved. Presumably a whole range of socio-economic factors were used in judgement by each individual involved. Lineage politics and personal friendships and animosities must also have influenced outcomes. Furthermore it is not possible to know whether some of the welfare factors (such as mortality/completed family size), were not actually also being used in the ranking exercise. It is only the strength of the relationship between cattle ownership and wealth rank that maintains my confidence that the measure was being consistently applied. Here again, though, as the term wealth can actually mean livestock (pfuma), and the fact of a pastoralist ideology, this only returns us to an aspect of problem (1) listed above.

(4) Equal numbers of households were allocated to each of four wealth ranks. This assumes that there is an undifferentiated continuum from the wealthiest to the poorest, with no functional role discontinuities (ie. 'class' centred phenomena). If there were qualitative differences in the position of different groups, such as female-headed households, permanent clients, people with semi-hereditary economic powers and so on (to pick a few truisms from the sample), this would invalidate the concept of grouped rankings arbitrarily allocated into quarters.

Despite the problematic issues described above, wealth ranks are sufficient for the rather cursory investigations carried out in Chapters Four and Eight; though even there I found myself pressing against the above limitations. What I try to do in these analyses is point to the fact that there are patterns and discontinuities deserving of attention, rather than trying to identify the actual causal relationships.

The wealth ranks were used in the analysis of assets, food production and consumption, and mortality, morbidity and nutrition including in relation to sanitation.

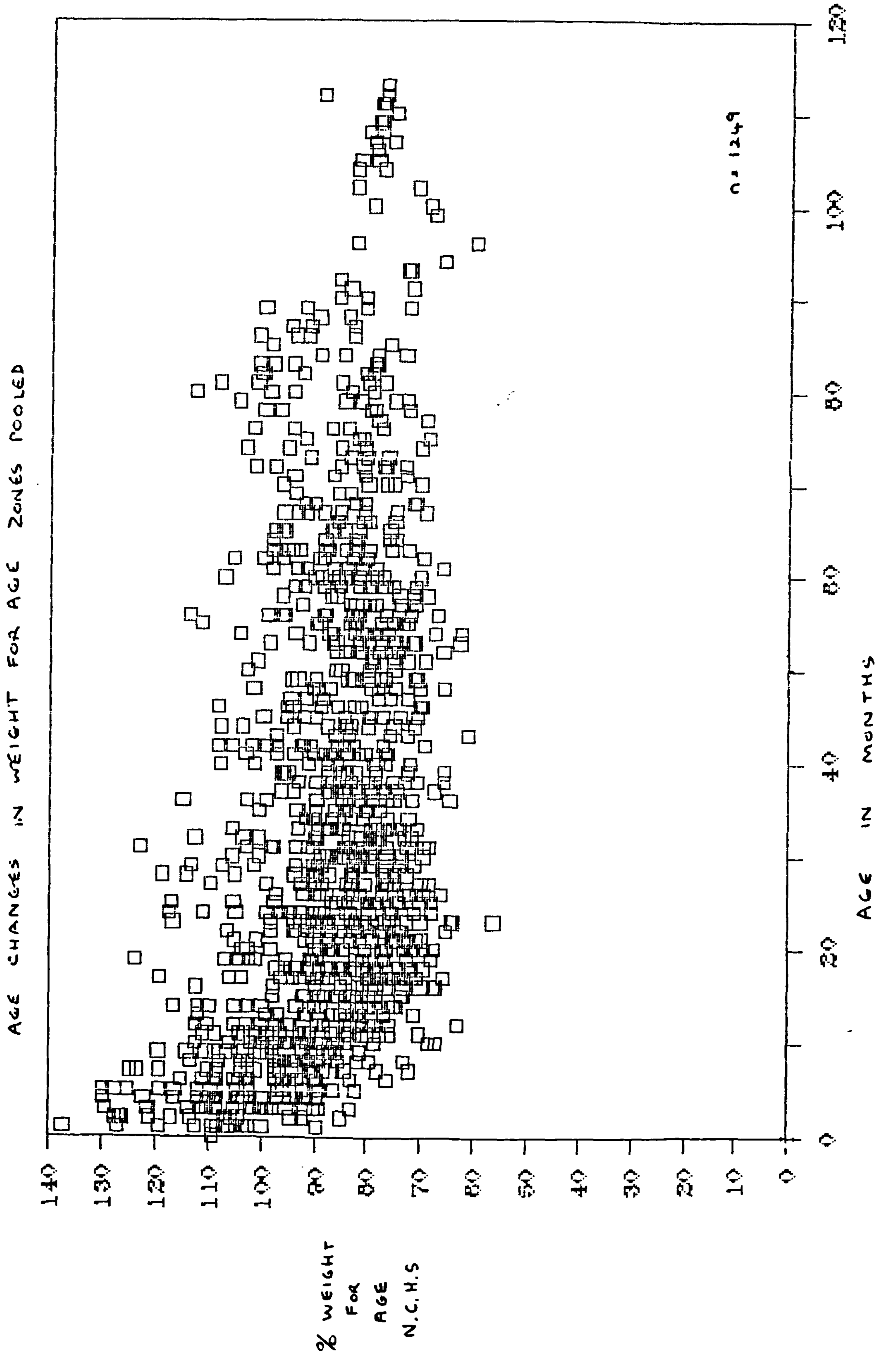
Using the anthropometric data

Anthropometric data have been analysed relative to NCHS standards (one of the data sets for healthy United States children). It is necessary to clarify why I have used these standards, and how I will interpret the results. The primary objective of the use of the standards is to compare sub-sectors of the Zimbabwean sample through time. For this kind of task it does not matter whether the anthropometric standards used are specially designed for the population in question, an elite group of that population, or one for well-off Caucasians, as the purpose is comparative analysis not clinical intervention.[19] I am only using the anthropometric standards to convert children into a single analytical frame, so as to compare populations. All that I assume is that lower anthropometric status implies the effect of a physiological stress, and itself produces a functional impairment.[20] Since the extent of functional impairment is open to debate, I have not relied on any assumptions concerning the severity of the relationships (see review in Chapter Seven, Section 7.2). This is also one of the principal reasons why I have presented a figure for mean anthropometric status, rather than a proportion below a given cut-off point, as if that cut-off is the moment of functional significance.[21]

The NCHS anthropometric tables used are those presented by WHO (1983), in which the sexes are assessed separately. For one analysis (core sample seasonal changes in weight-for-height) a different NCHS table was used, that in Simmonds *et al.* (1983), in which the sexes are averaged.

As my sample sizes are small I have pooled children of different ages in order to make comparisons between population sectors. In order to determine which age groups could be used for this procedure, and with the technical assistance of K.D. Jacob, I first plotted data for 1249 weight-for-age measurements against age (derived from Road to Health cards and my own studies). This showed that there was a marked decline in mean anthropometric status on NCHS standards from the ages of birth to one year old, but that after this weight-for-age remained essentially constant. There might possibly have been a decline over the age of seven years, when children start school. Parents say children suffer at this time from less frequent eating and from walking long distances. (See Figure 2.3.2.)

FIGURE 2-3-2
CHANGES IN WEIGHT-FOR-HEIGHT WITH AGE : ZONES POOLED



On the basis of the observation in Figure 2.3.2 on the relative constancy in mean weight-for-age post-infancy, and on the fact that NCHS expected weight gains are constant at around 2.2kg/annum from the ages on one to seven years, I have pooled one to seven year olds for the weight velocity studies. Two to ten year olds are used for the other anthropomtric assessments, height measures being discarded for the under two year olds.

Pooling children by sex is justified by the negligible differences found in anthropometric status between them (see Chapter Seven, Section 7.4).

Using the morbidity data

The morbidity data was derived from mothers' recall, and therefore I have not seen fit to convert it into biomedical terms beyond a minimal grouping of 'symptom groups'. Those utilized in the thesis are ear, nose and throat (ENT), gastro-entritis (diarrhoea, and other stomach complaints and vomiting), in this thesis this category is often simply called 'diarrhoea'; and 'sore eyes'. These symptom-groups so dominated morbidity that the other categories identified for analysis (notably 'headaches and fevers') are not even presented separately in Chapter Six. Furthermore, the degree of functional impairment and/or risk of death encountered with the different 'morbidity' factors was obviously not calculable. Therefore I have avoided hanging my argument on the severity of risk presented by any particular disease.

Age and sex prevalence/incidence curves have not been calculated for morbidity in order to divide the sample into 'natural' groupings. It was noted, however, that diarrhoea first increased in frequency around one year of age and then showed a marked decline with age over three years (as is typically found: eg. Leeuwerburg *et al*, 1984a: 111-2). Despite this, samples were not stratified by age, and there remains a danger that artifacts of age biases may affect resulting contrasts.[22] Sex differences in morbidity were minimal (Chapter Seven, Section 7.3), and therefore there was no problem with not controlling for sex in analysing sub-sample populations.

CHAPTER THREE

RAINFALL, SOILS, ECOLOGICAL DYNAMICS AND FARMING SYSTEMS

Introduction

My thesis is that an appreciation of ecological dynamics is essential for understanding the timing and intensity of seasonal and inter-annual variations in human welfare, variations which are a key feature in savannah environments. This approach is validated through comparison of adjacent populations living on contrasting soil types with fundamentally different ecological dynamics. In foundation for the thesis, this chapter documents how these soil differences affect the food provisioning and disease environment of the study populations. The focus is on the human ecological implications of spatial and temporal environmental variability, especially as a result of seasonal and inter-annual rainfall variations. In essence, the lower nutrient status and greater heterogeneity of sandveld results in a more stable production in the face of rainfall variability than is found in clayveld. This basic ecological productivity variation is shown to be reflected in food production and consumption (Chapter Four) and nutritional status (Chapter Five). Furthermore, the ecological differences between the sandveld and clayveld zones affect the transmission of several important childhood diseases, and in a seasonally and inter-annually contrasting manner (Chapter Six). Together, these have demographic implications (Chapter Seven), and socio-economic differentiation and historical changes in welfare only have an impact on population, health and nutrition in the context of the ecology of the production process (Chapters Four and Eight).

Seasonal and inter-annual variation in rainfall plays a driving force in the productivity and dynamics of semi-arid savannahs. Patterns of rainfall in the study area are examined, including the degree to which patterns in its variability and indigenous knowledge enable the population to predict rainfall, and therefore more effectively utilise it. (Section 3.1).

Section 3.2 investigates theoretical work on the contrasting pattern of plant productivity in response to rainfall variability as it is conditioned by soil-type. Due to high fertility and water demand plant growth in clayveld is restricted to the brief rainy season, and primary production each year largely reflects the amount of rainfall (Section 3.2.1). Sandveld productivity, by contrast, is constrained by plant-available nutrients as much as plant-available moisture. Higher rainfall is thus not as directly reflected in higher plant production in the manner that it is on clay rich soils. Indeed, in wet years, farmers can face a problem of leaching and water-logging on the sandveld soils depressing crop production (Section 3.4.1). Plant growth is also less seasonal on the sandveld soils. Herbivore and carnivore biomass are also markedly different between the two ecological zones, being generally higher upon the clayveld (Section 3.2.3).

Sandveld soil permeability leads to ground water accumulation, which is used by trees in the dry season (Section 3.3.1). Furthermore, this water seeps out into 'dambo' wetlands in the dry season enabling patches of continuous herbaceous layer production (Section 3.3.2). The soil-moisture regime of sandveld therefore plays a major role in the reduction of seasonal (and to some extent inter-annual) variation in primary production relative to clayveld.

The greater heterogeneity of sandveld leads to a mosaic of different micro-environments and patterns of primary production. This creates a more diverse cropping system than found on clayveld, and provides some functional stability, further ameliorating the primary productivity regime of sandveld seasonally and inter-annually (Sections 3.3.2, 3.3.3 and 3.3.4).

Sandveld heterogeneity, and the nutrient constraint results in greater species diversity on sandveld than on clayveld. This is reflected in the variety of wild foods gathered in that environment (Section 3.3.5 and Appendix One). The presence of rocky kopje outcrops and more fruiting trees within the sandveld results in large baboon populations. Baboons damage crops and kill goat kids, tie up many hours of labour in guarding in this zone (Section 3.3.5).

These basic ecological differences shape land-use strategies (Section 3.4.1). (A discussion of historical transformations of agro-ecological strategies is provided in Appendix Two.) Sandveld farming systems are directed toward overcoming soil nutrient constraints, whilst clayveld systems address the moisture constraint. Clayveld farming attempts to exploit brief pulses of production following heavy rains, which may come on average once in three years. Sandveld farming, on the other hand, is less seasonally restricted and not as constrained by inter-annual rainfall variation. However success on sandveld is dependent upon managing nutrient inputs and on warding off baboons. Farmers have developed switching between the two ecological zones on a seasonal and inter-annual basis as a response to contrasting seasonal and inter-annual variations in productivity (Section 3.4.1).

Underlying differences in ecological dynamics between the sandveld and clayveld are not directly and passively reflected in agricultural productivity or welfare. This is because farmers use strategies or various kinds to exploit and cope with variability. These strategies are broadly outlined in Section 3.4.2. Some moderate the impact of ecological processes on human welfare, whilst others are opportunistic and exploit and thus increase underlying variability.

3.1 Rainfall Pattern and Resultant Agro-Ecological Constraints

General Overview

Zimbabwe has been divided into five agro-ecological regions on the basis of rainfall and evapo-transpiration requirements (Vincent and Thomas, 1961). Only regions one, two and three have sufficient rainfall to provide economic returns for cropping under 'commercial' farming regimes. Regions four and five have such low and erratic rainfall that commercial farmers are recommended to engage only in forms of extensive beef ranching (and even for this the profitability is in doubt: Child 1989). The area studied falls under natural region five, and it is only through the development of specially adapted agronomic practises that farmers can grow crops. These practises are centred around low inputs to tackle critical constraints (Section 3.4.1), the exploitation of heterogeneity (Section 3.3), and a variety of different strategies to cope with variability (Sections 3.4.2, 3.4.3 and 3.4.4).

Rainfall in Zimbabwe is broadly a function of the inter-tropical convergence zone (ITCZ) which moves south over Zimbabwe rather intermittently during the hot season. Broadly speaking there is an association between altitude and rainfall, with the highest rainfall in the north-east of the country. There is some good rainfall data for the study region, but no long term record within Mazvihwa itself.[1] The Meteorological Department's national isoyhets are slightly different to what I derived directly from local rainfall station data and extrapolated to the Mazvihwa study area. Overall a mean rainfall of around 500mm is suggested from these sources, with some of the lower clayveld below 500mm and the central hilly area of sandveld perhaps nearly as much as 550 - 600mm.[2] One group of rainfall stations in this region recorded precipitation nearly twice as crop-effective as another group, for which there were no obvious explanations.[3]

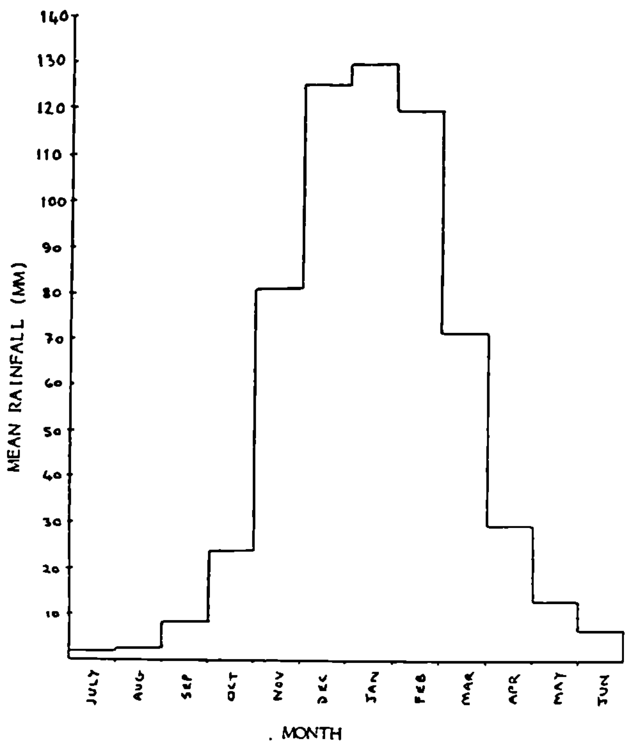
As is characteristic of many African peoples in semi-arid areas, rainfall is said by 'Shona' peoples to be controlled by 'spiritual' factors.[4] Local and national politics, and local land-use practices are believed by most people to be able to have a direct impact upon rainfall levels.[5] There is an extremely widespread but incorrect belief that rainfall is actually declining, attributed by locals to a desecration of the land through the subordination of indigenous political economies and culture to state and capitalism, and also to associated deforestation.[6]

A variety of indigenous terminologies for rainfall types were recorded, but most of them contain clear reference to the same specific categories with an identifiable meteorological basis (descriptions of winds, cloud formation and rainfall were extremely astute). People's use of these terms can convey such important things as the agricultural significance of the rainfall, and its likelihood of continuing.[7]

3.1.1. Seasonality

A characteristic of savannah regions is the highly seasonal nature of rainfall distribution. Figure 3.1.1 shows the mean monthly rainfall distribution for the pooled local stations adjacent to the study area.[8] Nearly ninety per cent of the rain falls in the November to March 'rainy season', with about sixty per cent of total in December, January and February alone. In practise most of the rainfall occurs in a few big storms.[9] There is enormous variability within each rainy season, resulting in frequent mid-season droughts. Co-efficients of variation for individual months are between 100 and 250%. Despite the variability of the rains there are still broad seasonal changes that are relatively well defined in this area.[10]

Figure 3.1.1 Mean Monthly Rainfall Distribution in Study Region

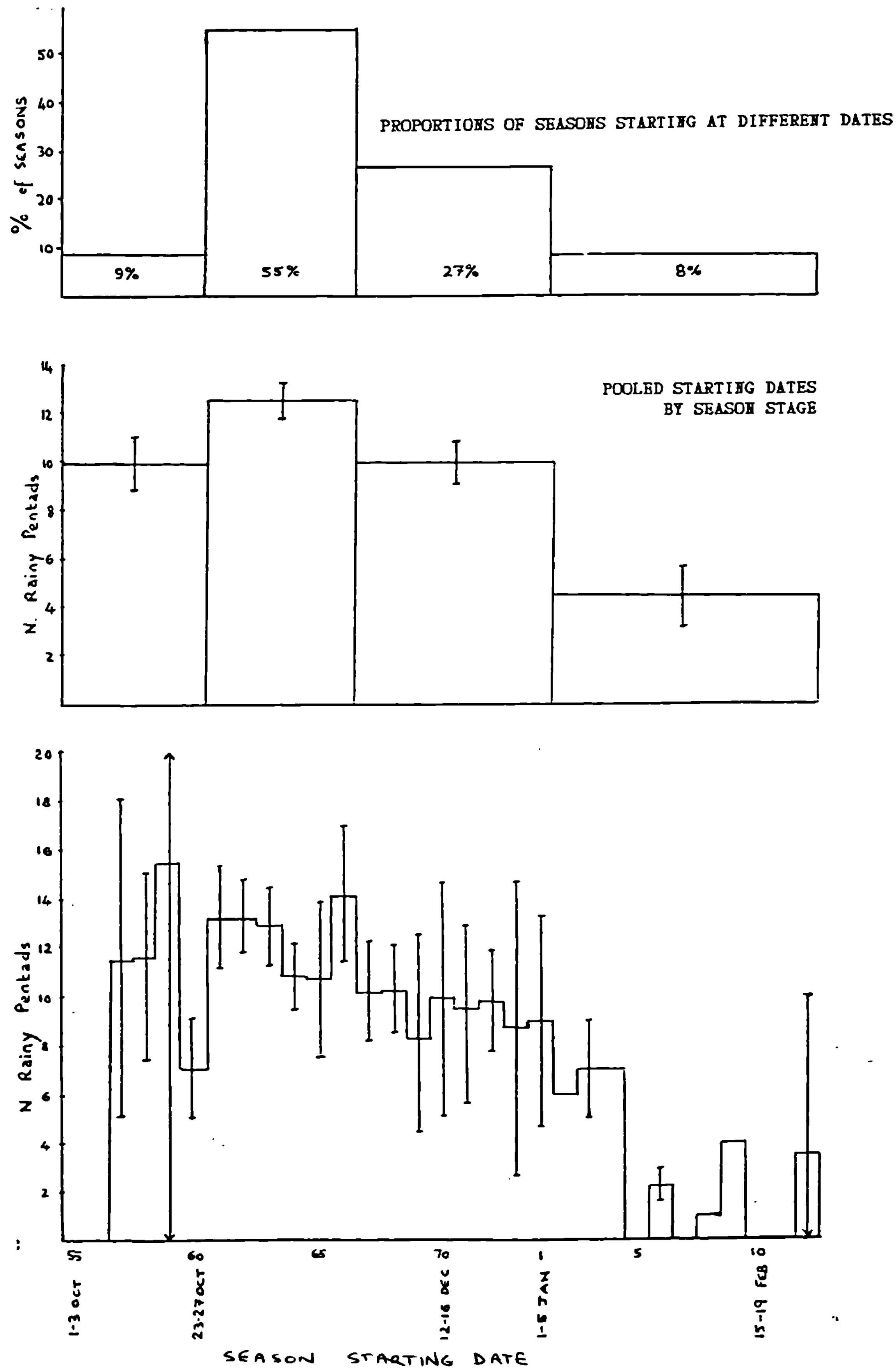


This rainfall seasonality means that the plant production dependent upon incident rainfall is only possible for a brief period during the year. Yet due to the high potential evapo-transpiration, if rainfall were evenly distributed through the year little could probably grow at all. It is therefore precisely this concentration of rainfall that enables significant plant growth, even if it does confine it to a brief period of the year. As pointed out by the ICRA research team (using data from neighbouring Chivi), even during the rainy season mean precipitation in only twenty five percent of pentads will exceed the potential evapo-transpiration of 25mm per pentad (Balderrama *et al.*, 1988: appendix E-4).[11] Therefore, under these low levels of rainfall, the concentration of rainfall does not lead to the creation of seasonal excesses; rather it enables brief periods that approach adequacy. The critical issue for arable production under such conditions is timing the operations so as to make maximal use of this rainfall.

FIG 3.1.2

SEASON QUALITY BY SEASON STARTING DATE: LOW RAINY PENTAD STATIONS

Season starting date: date of first rainy pentad; Season quality: number of rainy pentads. Confidence intervals are 95% Total N: 241



Onset of the Rains

The onset of the rains is extremely variable, as shown by an analysis I undertook of season starting date (date of first rainy pentad), using data for 241 seasons at nearby stations.[12] There was little variation in starting dates between these stations analysed. Figure 3.1.2 shows that fifty five percent of starting pentads were between pentads 28th October/1st November and 22nd/26th November.[13] This level of variability means that though farmers are orientated towards a November start to the season, they cannot be sure, and can anticipate any downpour between early October and late December to be the rainfall that initiates the season. The possibility that the date of onset of rainfall can predict overall season quality is investigated in Section 3.1.3.

Mid-Season Droughts

Even during the rainy season rainfall itself is rather patchy so that mid-season droughts frequently damage crop growth. In the data pooled for the Zvishavane District stations (Figure 3.1.1), January shows on average the highest rainfall. However, farmers complain bitterly of mid-season droughts at this time, which particularly tend to hit maize at flowering (tassling) when it is very vulnerable. The seriousness of soil-moisture deficits in January may not only be because of the very slight bimodal rainfall pattern, which may anyway be restricted to only some of the areas experiencing the problem.[14] Evapo-transpiration may be higher in January due to greater crop requirements than earlier.[15] The same level of rainfall shortfall in January will therefore result in a greater deficit for the crop. January temperatures are considerably higher than those in February, especially those in dry periods. Evapo-transpiration is thus higher in January despite the higher plant biomass in February. This again would result in more rapid onset of moisture-stress during rainfall failure in January than February.

3.1.2 Inter-annual variability in rainfall

According to Zimbabwe Meteorological Department data, most of southern Zimbabwe has annual rainfall co-efficients of variability of around 30% and above. Stations in the study area show levels about 35% and this means year by year differences of several fold. Data for deviation from mean annual rainfall[16] for the nearest long term rainfall station are presented in Figure

3.1.3. This demonstrates that few years experience rainfall close to the mean, and emphasises the significance of the threat of rainfall variability on plant productivity dynamics and human agro-ecological strategies.

Figure 3.1.3 Deviations from Mean Annual Rainfall: Chivi Station

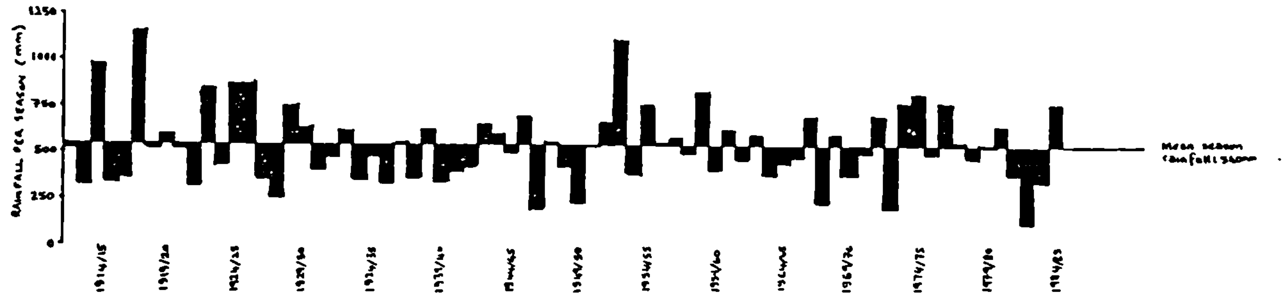
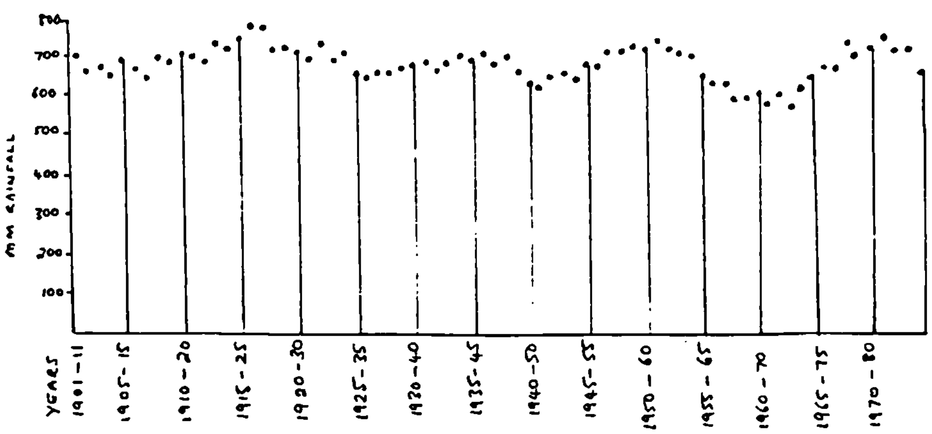


FIG 3.1.4 NATIONAL LEVEL RAINFALL CYCLES: 10 YEAR RUNNING MEANS 1901 – 1984.



SOURCE: HARARE MET. OFFICE

Underlying Cycles in Annual Rainfall

Figure 3.1.4 shows that despite the erratic nature of year by year variations in rainfall there appears to be an underlying rainfall 'cycle' evident in the Zimbabwe data. Detailed statistical study has been made of the southern African rainfall system indicating that the cycle (ten years wet, ten years dry) has a virtually predictive component (Tyson, 1978).[17] Whether or not there is a deterministic rainfall cycle, there has been a broad fluctuation in rainfall whereby the 1940s, 1960s and 1980s were dry, and the 1950s and 1970s wetter, and the ecological history of the twentieth century has been much affected by the fact of this changing pattern of rainfall.[18] The existence of wet and dry runs of years may lead to enhancement of both times of welfare stress and of plenty; indeed it appears to act as a demographic pump between sandveld and clayveld (Chapter Seven).

3.1.3 Predictability of Rainfall

It would be immensely valuable to farmers be able to predict the onset of the rains, so as to be able to use the first nutrient flush and achieve sufficient length of growing season. The time of year in 'absolute' terms can be gleaned through observations of the phenologies of a few temporally-determinant plant species, by noting the positions of the sun's rising and setting, and nowadays, simply by following the western calender.[19] However, as discussed above the actual start of the season varies considerably in calender date, so such information is not sufficient for predicting onset.

Animal activity indicators can be used to predict that rains will soon fall, for example high activity of **matheza** (*Hodotermes* spp: harvester termites). Some plant phenologies are also interpreted as indicators, for example the flowering of *Schotia brachypetala*. Oguntoyinbo and Richards (1978) and Richards (1985:47) discuss similar indicators in West Africa, and there is a passing reference in A. Richards, (1939). But more important than such indicators is the close observation of meteorological processes.[20] People give special attention to the form in which winds, cloud and rainfall come, in order to predict the likelihood of heavy rains continuing. Rains which come with the inter-tropical convergence zone are said to provide the most persistent rainfall (see note 7 for indigenous terminologies).

There is always much speculation about whether the rains in the coming season will be good or bad,[21] but on the whole people remain optimistic and this is very important in encouraging them to make good agricultural preparations. Stars can also be read in this regard, though this is not common. The position of the Pleiades indicates either **zhara** (hunger) or **kuguta** (repletion).[22] Indicators of a more religious nature, such as the burning of sacred mountains, can also be used. However, though much interest in spiritual indicators was developed in interaction with me as an anthropologist, these are unlikely to be much used in practical rainfall prediction, serving rather more as explanations and political ammunition against rival lineages.[23]

In some semi-arid areas of Africa season starting date shows a strong correlation with total precipitation and season length (eg. eastern Kenya: Stewart and Kashasha, 1984). Starting date can therefore be used by farmers to gauge coming season quality, so that they can 'response farm' adapting their practises to the amount of rain expected (eg. in chosing which varieties to plant and how much manure to use). Data for the number of rainy pentads received as a function of starting date are presented in Figure 3.1.2.[24] There is no simple decline in season quality with starting date, apart from with very late seasons starting in January or after. With starting dates pooled, the graph suggests a slight improvement in November starts over October starts, and a slight decline in December starts, whilst January and February starts receive only an average of half the number of rainy pentads received with earlier starting dates. Yet only 8% of seasons start in January or later, so only a negligible number of seasons can be predicted as markedly poor on the basis of starting date.

Prior to carrying out this analysis farmers were interviewed about the potential for predicting season quality from starting date. Farmers told me that starting date was a very poor indicator of season quality, and that given the variability of rainfall it was best to disregard any inferences. They were aware that early (October) starts can be unreliable and are fearful of mid-season droughts in these years. Several old farmers also told me that seasons starting after late November are liable to be slightly poorer. As people compete over rainfall prediction and commit seasons to memory I was told specifically the 25th and 27th November by two informants, Mr Mukamuri and Mr Magwidi. These dates are uncannily close to those produced by the analysis undertaken above. Failure to start by Christmas is generally recognized to herald a drought year. Thus certain farmers are aware both of the precise relationships between starting date and quality, and also of their limited value in making farming decisions.

Some indicators in the dry season preceding the rains are said to inform farmers of the quality of the subsequent rainy season. Very high temperatures are required to initiate good rainfall, an observation generally supported by meteorologists (eg. Torrance, 1983). A number of indigenous fruit trees are said to fruit more heavily before droughts.[25] Heavy fruiting by other species such as *Lannea discolor* is taken as predicting a high rainfall season.[26]

3.1.4 Conclusions and Implications

The study region is semi-arid receiving an average of around 500mm/annum in a single season. More than half of the rainfall falls (on average) in only three months of the year. Season starting date is very variable, and there is a high probability of mid-season droughts. Co-efficients of inter-annual variation in rainfall are as high as 35%. There appears to be an underlying cycle in rainfall, with alternating wet and dry decades. Given the variability of rainfall local people make considerable effort to predict future season quality, but this appears impossible, though most elderly people are good at interpreting the implications of weather over short time periods of up to one or two weeks. This helps plan farming operations, but does not enable people to overcome operating an unpredictable system.

This discussion of rainfall aims to highlight the extent of rainfall variation in this region, since the impact of this very variable and highly unpredictable rainfall pattern on human welfare is the main theme of this thesis. The following sections of this chapter demonstrate the contrasting effects on plant productivity of this rainfall variation observed in the two ecological zones studied. Whilst sandveld shows an ameliorated plant productivity regime, on clayveld the level and timing of plant growth reflects incident rainfall.

3.2 Productivity Characteristics of Different Soil Types

In this section it is established that soil factors intervene between incident rainfall and plant productivity, conditioning the effect of rainfall variability on ecological dynamics. The contrasting plant productivity responses to rainfall variability of the two ecological zones investigated are established in detail as they provide the base-line hypothesis for this thesis. These differences are demonstrated to affect the nature and temporal patterning of food production and consumption, both through hunting and gathering (Appendix One) and agriculture (this Chapter, 3.4 and Chapter Four). The contrasting behaviour is then shown to be reflected in nutrition (Chapter Five), morbidity (Chapter Six) and fertility and mortality (Chapter Seven).

3.2.1 Relations between rainfall variability and plant productivity

Primary Production: principles

Broad correlations between warmth and wetness and ecosystem productivity are well established at a global level (eg. Leith, 1975). Within the semi-arid tropics, where temperature differences are relatively minor compared to those in precipitation (and low temperature is rarely a constraint to plant growth), there has been a correspondingly greater attention to the effects of rainfall on productivity. In an early and much quoted paper Walter (1939) established a regression between rainfall and production in Namib grasslands of 1g m^{-2} y^{-1} for each 1mm rainfall. Rutherford (1981) has since shown that this was based on poor and rather manipulated data, but nevertheless similar (though less steep) regressions have been obtained by others. A literature survey by Desmukh (1984) of mainly East African data produced a regression of 0.8g m^{-2} y^{-1}/mm rainfall, and similar relationships have been shown in the Sahel/Sudan and Mediterranean systems by Le Houerou and Hoste (1977). These studies have used peak herbaceous biomass as the measure of productivity, which is inadequate for many reasons, including the presence of woody plants and death and consumption during the season (criticisms of this are provided by Desmukh and Baig, 1983; Desmukh, 1986, Le Houerou and Hoste, 1977 and Rutherford, 1981).

Precipitation is not the only factor affecting herbaceous productivity. Soil fertility and soil-moisture relations are particularly significant (Desmukh, 1980), and can have an effect as great as an order of magnitude [ten fold] (Houerou and Hoste, 1977). In the Sahel nutrient (N/PO_3) levels have been shown to have a limiting effect upon primary productivity (Breman and De Wit, 1983). In the wetter regions in particular, critical shortages of N develop such that herbaceous growth ceases prior to soil-moisture depletion (Breman and De Wit 1983:1342).

Grass/Herbaceous Layer Productivity Dynamics: sandveld and clayveld contrasts

The relationship between precipitation, soil nutrient status, and herbaceous production has been elucidated most clearly by the work of Dye and Spear (1982) in Zimbabwe. Regressions were obtained for fifteen to nineteen year periods in four sites with different soil types.[27] The most interesting results are from adjacent plots, the thornveld (clayveld) and sandveld plots at Matopos, as these are the same soil types as are being compared in Mazvihwa. Mean rainfall is 615mm and altitude 1340m, so the area is rather higher and wetter than Mazvihwa (c.500mm and 850m respectively). Yet the vegetation remains broadly similar to that in Mazvihwa, except that *Acacia* has more completely replaced *Colophospermum mopane*. In both sandveld and clayveld sites herbaceous production increased with precipitation, but the correlation was much greater in clayveld (r^2=0.84) than sandveld (r^2= 0.39). Furthermore the increase in herbaceous production with increased rainfall was much steeper on clayveld ($y= 3.58x - 415$) than sandveld ($y= 1.20x + 671$). Basically the same five-fold rainfall variation (between the wettest and driest years) produced a six-fold range in herbaceous layer production on clayveld, but a three-fold difference on sandveld. Herbaceous layer standing biomass during a drought (1986-7) and a fairly wet year (1987-8) in Mazvihwa showed a broadly similar result, with a greater difference in biomass in the clayveld samples than sandveld (Ian Scoones pers. comm. 1988).

The explanation for the greater relationship between precipitation and herbaceous production on clayveld is largely the effect that clays have on soil nutrients and plant-available moisture. Clay-rich savannah soils tend to have higher nutrient status than sands because they are younger, derived from more base-rich rocks, and less weathered because they are found in areas of lower altitude and rainfall. Importantly the effect of the frequently high proportions of 2:1 lattice clays is to contribute to high cation exchange capacities and hence higher levels of exchangeable bases. (Frost *et al.*, 1986). The effect on plant-available moisture can be aptly summed up by Walter's adage (1971), that clay rich soils are drier when they are dry but wetter when they are wet. The clay minerals bind moisture and reduce the plant-availability when the soil is dry. However, when there is high rainfall, moisture builds up and can saturate the as the clays reduce the permeability of the soil. Such clayveld soils in southern Africa have been labelled 'eutrophic' by Huntley (1982); and the interaction between the clay content, water relations and fertility of these low veld soils has long been recognized by soil scientists in Zimbabwe (Ellis, 1953:10-13).

Sandveld soils are derived from base-poor granites and gneiss on ancient plateau, and are more highly weathered and leached. Therefore soil fertility is much lower and acts as a major constraint to plant productivity. For this reason these soils have been characterised as 'dystrophic' (Huntley, 1982). Soil moisture is more plant-available, as it is less bound to clay minerals, so that plant productivity is less constrained in drought. Heavy rainfall not only makes more acute the imbalance between nutrients and soil-moisture as growth-limiting factors on sandy soils, it also directly reduces plant-availability of nutrients by leaching. Therefore increased water supply does not lead to the same degree of productivity gain as it can on clayveld. (Frost *et al.*, 1986).

Woody plant productivity dynamics: sandveld/clayveld contrasts

As mean annual precipitation declines Miombo woodland grows on soils with progressively lower clay content: whilst it is found on clayveld in the high veld (Watson, 1975:148 and personal observations), in Zvishavane it is restricted to sandveld. The trees of this Miombo woodland found on sandveld basically grow just prior to the start of the wet season using nutrient reserves stored from previous years (Rutherford and Panagos, 1982). Due to the high underground biomass characteristic of these trees, shortfalls in production in any given season due to factors such as drought and plagues of caterpillars (see Appendix One), can be made up from longer term reserves and growth from year to year varies little (Frost *et al.* 1986:35). In contrast 'eutrophic' savannahs, such as the clayveld area in Mazvihwa, contain trees characteristically displaying indeterminate growth reflecting the conditions in the current season (Walker, 1985:83-4; Frost *et al.* 1986:29). High rainfall years are therefore times of exceptional tree growth in clayveld but not sandveld.

On sandveld tree fruiting occurs throughout the year (see Appendix One for phenologies). Fruiting levels of sandveld trees tend also to be independent of rainfall, with even some evidence that fruiting is much heavier in dry years than wet years (Malaisse *et al.* 1975; Peters and Maguire, 1981:575; Nurse *et al.* 1985:248; see more detailed review in Appendix One). On clayveld, fruiting is largely during the rains or immediately afterwards (Appendix One), and generally speaking high rainfall years are followed by high fruit production. Therefore there is greater seasonal and inter-annual variability in fruiting on clayveld.

Seasonality of plant growth

Seasonality of plant growth in sandveld is less marked than clayveld.

Trees leaf-out prior to the rains and keep their leaves for longer on sandveld; on clayveld leaf-out is only after heavy rain has fallen, and except in very wet years trees begin to defoliate shortly after the end of the rains. This is due to ground water availability in sandveld. (Section 3.3.1 reviews this topic in detail.)

Early season showers bring about a flush of grass growth on sandveld much more quickly than clayveld. This is because the clay minerals in the clayveld soil binds more of the early moisture (to make it not plant-available). This effect was very noticeable in 1986-7 when grass cover had become established on the sandveld well ahead of the clayveld.[28]

At the close of the rains clayveld herbaceous layer vegetation tends to cease growth and dry up more quickly than sandveld. This reflects the fact that a much larger proportion of the moisture in clayveld soil is not plant-available. In very wet years this effect may be much less marked, because the clay soil can hold large quantities of moisture for longer than can the sandy soils.

3.2.2 Rainfall, Soil Nutrients, Herbivore and Carnivore Biomass

Phillipson (1975), Coe *et al.* (1976) and Bell (1982) have shown that the rainfall - primary productivity relationship is also reflected in herbivore biomass.[29] Surveys of domestic stock biomass in Kenya by Watson (1972, quoted in Bell, 1982) have come up with similar relationships. Bell (1982) drew attention to the fact that soil fertility (assessed on the basis of the base-geology as discussed above) was able to explain most of the residual variance after regressing the effect of rainfall on the biomass of wildlife, livestock and human populations. Biomass and populations were higher than predicted by rainfall alone where the soil was fertile, and lower when less fertile. Bell (1982:207) suggests that the effect is caused by the impact of soil fertility on vegetation quality (described in terms of the ratio between metabolites and structural compounds). Herbivore biomass will be a function of soil fertility because of the effect of edibility, which is more significant than that of plant biomass. Additionally he predicts that nutrient shortage in soils will lead plants to invest more in defence (1982:212-3), and more recently Cooper and Owen-Smith (1985) have shown that secondary chemical inhibition is important in southern African savannahs.[30]

Dramatic differences in animal biomass across boundaries are well known between miombo sandveld and clayveld and volcanic soils in Africa. They have been described for large mammals (Bell 1982:193, Owen-Smith 1982:359-404); and for phytophagous insects and birds, in Nylsvley, northern Transvaal, RSA (Huntley and Morris 1982:448-9 and 1982:446-7 respectively).

This discussion would suggest that in this case study livestock and human population densities should be higher in the ecological zone with the soil of higher fertility. Human population density is slightly higher on the clayveld than sandveld, and this does in part reflect the greater sustainability of cropping these soils (as well as the problem of the sandveld baboons: see 3.4). Yet differences in population density are small. The lack of significant difference reflects the fact that in such a dry area the benefits of higher fertility are counter-balanced by the effects of enhanced moisture constraint. Neither environment is 'better' for habitation, rather the constraints and dynamics are different between them.

3.2.3 Conclusions

Plant available nutrients and moisture act as interacting constraints on savannah plant productivity. The 'sandveld' and 'clayveld' ecological zones studied are limited by nutrients and moisture respectively. As clayveld is moisture limited its herbaceous layer productivity tends to track rainfall variability more closely than it does on sandveld. In miombo woodland on sandveld woody biomass growth is fairly independent of variations in precipitation on a seasonal and inter-annual scale. Clayveld woody biomass tends to produce opportunistically to reflect rainfall events and levels. Seasonality of plant growth in sandveld is less marked than clayveld. Trees leaf-out prior to the rains and keep their leaves for longer on sandveld. Early season showers result in grass growth on sandveld much more quickly than clayveld. At the close of the rains clayveld herbaceous layer vegetation tends to cease growth and dry up more quickly than sandveld, except in very wet years, when the clay soil can hold moisture for longer.

The level of soil fertility can have important effects upon secondary and tertiary productivity. In this study area the rainfall is sufficiently low for nutrients and moisture to act as approximately equally powerful contraints so that the more nutrient rich soil is not overall more productive. Differences in the variability of that productivity and the strategies this elicits from farmers are much more significant.

3.3 IMPLICATIONS OF HETEROGENEITY:

Part A: The stability of sandveld productivity due to the moisture regime

Section 3.2 has established that sandveld primary productivity varies less with rainfall than clayveld productivity. Yet the productivity relations of individual pieces of sandveld versus clayveld do not reveal the true degree by which sandveld is buffered against the effect of rainfall variability on productivity. The aim of sections of 3.3.1 and 3.3.2 is to describe additional stabilising factors of sandveld productivity resulting from the permeability of sandveld. 3.3.1 considers the effect of dry season groundwater on trees in sandveld, and 3.3.2 the role of sandveld wetlands (dambos). The significance of greater catenal development and the variability of soil nutrient status on sandveld are discussed in sections 3.3.3, 3.3.4, 3.3.5. and 3.3.6. This heterogeneity has a considerable impact upon farming systems and upon the use of hunted and gathered wild resources (see also Appendix One). The presence of kopje hills and wild fruits also supports large baboon populations which are a great problem on sandveld, especially by raiding crops in the rains and harvesting seasons.

3.3.1 Groundwater and dry season tree leaves and fruits

Due to the high permeability of sandveld soils there is higher rainfall infiltration. This leads to greater storage in the sub-soil for the dry season, when it is tapped by trees. This ameliorates seasonality.

Sandveld trees remain in leaf longer than those on clayveld, especially in dry years.[31] Dry season groundwater availability enables dry season fruiting by the diverse miombo flora, and greater fruiting in drought years (see 3.2.1 and Appendix One).

A further contribution of dry season water availability on sandveld is the possibility of leaf out prior to the rains.[32] This leaf flush provides valuable browse for stock and game at a time when there is little grass and it is of very low quality on sandveld (except in dambos, see 3.3.2).[33] A variety of ecophysiological and hydrological researches have thrown light on the processes that enable the leaf flush prior to the rains in miombo sandveld.[34] In contrast mopane woodlands on clayveld do not produce new leaves until good rains have fallen.[35]

3.3.2. Catena and wetland development

Sandveld dambos and clayveld pans

The higher infiltration and permeability of sandveld soils relative to those of the clayveld also leads to lateral flows of water from the crest zones down slope with seepage into 'dambo' wetlands in the valleys and depressions below (Whitlow, 1984b:135).[36]. Infiltration on clayveld is less than sandveld,[37] and there is little sub-surface lateral flow due to low permeability and high field capacity, as well as the gentle clayveld gradients. During the bursts of heavy rain, however, surface flow is considerable on clayveld. Much of water flows away in gullies and streams, but some collects in depressions ('pans'), which southern Shona refer to as **makawa**. These are distinguished from dambos (which Karanga call **makuvi** or occasionally **matoro**), in that **makawa** basically receive wet season surface run-off, rather than wet and dry season sub-surface and (occasionally) surface run-off as do the dambos.[38] In Mazvihwa the absence of dambo-like features on clayveld is marked. However, under the much higher rainfall and lower evapotranspiration of the highveld dambo-like features can develop on red-clay soils; furthermore in areas of steep schist-derived red soils elsewhere in this district black cotton soils have developed.[39]

The surface pans of clayveld and the dambos of sandveld play rather different roles in the seasonal and inter-annual productivity dynamics of their respective ecological zones. Sandveld dambos under this rainfall and geological regime essentially stabilise productivity both seasonally and inter-annually. The reasons for this are explained through discussion of their hydrology (below). In contrast the clayveld pans have overall less marked effects on clayveld ecological dynamics, weakly stabilising seasonality and slightly exacerbating rather than stabilising inter-annual variability. The weakness of the effect is because whilst dambos occupy around 15 to 20% of the land area of sandveld in this region,[40] pans probably occupy less than 1% of clayveld. Seasonal effects of pans are limited as most of them dry up quite early in the dry season, though there are some which last the whole year.[41] Pans enhance inter-annual variability as their volume increases exponentially with rainfall because the proportion of rainfall that runs off rises as the soil gets wetter and seals more quickly.[42] Additional plant productivity experienced in these seasonal swamps therefore accrues disproportionately in wet years.[43]

Dambo morphology, soils, hydrology and vegetation

Dambo morphology is extremely variable reflecting many factors including bed-rock chemical composition and structure, geomorphological history, climate and vegetation.[44] A useful distinction can be made between sweet and sour dambos. The sweeter dambos have higher pH and clay content and produce nutritious fodder grasses for grazing and provide good agricultural opportunities. Not only are the soil characteristics better for nutrient-demanding plant growth, the kinds of geomorphological characteristics that lead to sweet dambos are correlated with those leading to an ameliorated hydrological regime.[45] Dambos in the study area are essentially 'sweet' and thus have higher inherent fertility than the surrounding toplands. Furthermore, compared to toplands, these Mazvihwa dambos show a higher return to nutrient inputs (due to greater plant availability of nutrients under higher pH) and also less leaching (due to their bottomland status and the greater cation exchange capacity). This is important because it is only certain kinds of dambos in certain kinds of landscape and climate that will act in the stabilising manner discussed in this thesis.

Dambo soils are highly variable in organic matter content (eg. Loughborough, 1987b:138-9), this is generally taken both as an indicator of their water-logging and as a cause of their high productivity.[46] Although organic matter in Mazvihwa dambos may be important, it should be recognized that it is principally their clay content and hydrological regime that makes these areas specially productive in Mazvihwa.

To understand the agro-ecological role that dambos play in the sandveld zone it is necessary to briefly review their hydrology. A significant misconception is that they act as 'sponges', storing up wet season rainfall, releasing it to streams in the dry season.[47] However, as Rattray *et al.* (1953:467-8) argued long back, it is the sandy upland soil that acts as the aquifer (sponge) releasing the water into the bottom land dambo (see also Thompson, 1972:153).[48] Rather than acting as sponges feeding streams in the dry season, dambos act as plugs which make seepage water from topland available for plant growth. Most of the water entering the dambo is transpired off and - to a lesser extent - evaporates, before reaching the stream.[49] This means that it is the upper dambo margin that tends to be the wettest during the dry season, and is therefore used for wells and vegetable gardens.[50] Interpreting dambos as sponges leads to an incorrect conception of how they stabilise seasonal and inter-annual rainfall variability; just as it leads to incorrect reasoning about the nature and seriousness of their degradation and how they can best be used for agriculture (Elwell and Davey 1972:156; Mharapara 1985:22; Loughborough, 1987a:13-6 and 1987b:111-3).

Dambo water tables in many catchments rise prior to the onset of the rains, the explanation for which is still uncertain.[51] This promotes a flush of new grass growth for grazing, which may anyway be encouraged by an increase in temperatures.[52] Cropping is also initiated during this period (August-October), so as to utilise this moisture (see also Cripps, 1931:44). Early planting is possible on dambos because even if there are early season droughts the crop will not be damaged. Early planting is desirable to spread agricultural labour inputs, to secure early harvests at a time of peak food prices, and to enable double/relay croppping in favourable years. Thus the inflow of water into dambos during the dry season makes a considerable contribution to ameliorating sandveld seasonality.

Dambo areas form edaphic grasslands as miombo trees cannot cope with waterlogging (Robyns, 1937; Michelmore, 1939; Tinley, 1982:187-9). Rock outcrops, termite mounds and invasive gulleys typically support trees (Cole, 1963:298 and Mackel, 1985:7), and the better aerated soils around springs frequently support *Ficus* spp. or *Syzygium*. Winter frost (due to inflow of cold heavy air into lowlands) may also play a role in suppressing tree growth (cf. Gilliland, 1938:94, Rattray *et al.* 1953:204); and fire control in these grassland patches can result in some tree invasion (by *Syzygium*) at the margins (Rattray *et al.* 1953:474). It is the seepage into dambos in the dry season which prevents tree establishment, in a run of low rainfall years trees can invade dambo areas, and then maintain them dry due to their high evapotranspiration,[53] until waterlogging is brought on by very wet years (Tinley, 1982:187-9). In highveld areas the lack of trees and impeded drainage of the dambos means that incident rainfall in the wet season is sufficient to make them flood at this time,[54] but in dry areas such as Mazvihwa wet season run-off appears to also be important. Hydrological models of dambos which ignore the dynamic role of vegetation are therefore inadequate.

Dambo usage and seasonal and inter-annual variation in productivity

The presence of dambo wetlands maintains grass production during the dry season and so provides a significant grazing resource during the dry season in sandveld.[55] A small cattle herd was surveyed by Scoones for one day/month over one year on the boundary of the clay and sandveld zones in Mazvihwa. It concentrated upon fields and contour ridges in the early dry season, and then in the late dry season spent a third of its time on dambo land, even though this comprised less than five per cent of the land within a two kilometre radius of the homestead (Scoones, 1988a). It was notable, however, that dambo land was even more significant during the rainy season for this herd.

Dambos are also used extensively for cropping in the sandveld area of Mazvihwa, though this is technically illegal.[56] (Historical dynamics in dambo usage are discussed in Appendix Two, and by Maseko *et al.* 1988.) In the parts most prone to waterlogging, rice and maize tend to be intercropped, often together with cucurbits. If the rainfall is high, the rice will yield well, whilst if there is little rain the good maize yields will compensate for little rice production.[57] In the rest of the dambo land farmed maize, millets and ground nuts are most frequently grown. Planting of dambos is possible prior to the rains due to rising water tables in the late dry season. This is further enhanced by some farmers through winter ploughing dambo lands so that residual moisture from the previous season is maintained at rooting depth. Successful dambo agriculture requires considerable and timely inputs of draught power, and so in this region extensive dambo farming is only preferred by the wealthy.

The high water table in the dambos during the dry season facilitates winter gardening of *Brassica* spp., tomatoes, onions and certain other vegetables for home consumption and sale (Loughborough, 1987a and 1987b). Production of vegetables is undertaken in the dry season as this is when the need - and market - for relish is greatest, when there is the lowest opportunity cost to labour, as well as being when vegetable pests are least prevalent. These gardens are typically watered from shallow wells to supplement existing soil moisture. In the clayveld zone gardens have to be made along rivers and streams, but at least thirty metres from the bank due to national law (see note 56). More watering is generally required because there is lower existing soil moisture, and the vertical lift and distance for carrying is much greater. National policy is forcing abandonment of individual gardens in favour of group gardens, a few of which are receiving inputs from government and aid agency programmes.[58]

Dambos in the sandveld of Mazvihwa stabilise inter-annual productivity in three ways. Relative to topland dambos water tables are more stable, plant production varies less with moisture variability, and the economic value of (admittedly decreased volume) of dambo production is greater during drought. It should be stressed that this stabilising behaviour reflects specific circumstances of the Mazvihwa agro-ecosystem, and that dambos cannot be assumed to play this role in all regions.

Dambo water table levels do not vary as much as rainfall levels, because groundwater in the catchment aquifer acts as a reservoir ameliorating the level of infiltration. During wet years water is accumulated to compensate for falling water tables in dry years.[59] It should be noted, however, that there is a counterwise trend toward an increased proportion of incident rainfall entering the dambo during high rainfall, which tends to destabilise the system. This is due to the fact that plant growth (and hence evapotranspiration) does not increase in proportion to rainfall due to the fact that nutrients also act as constraints upon plant growth (3.2.1). The strength of this destabilising influence will increase the higher the rainfall, and the lower the fertility. In the dry sandveld of Mazvihwa its effect is probably weak.

Fluctuations in dambo moisture levels consequent on variable incident rainfall and infiltration have less effect upon plant productivity in dambos than does rainfall variability on the topland. This is because high and low moisture inputs each have both beneficial and negative impacts upon crop productivity. Therefore the overall volume of dambo production tends to be relatively stable compared to topland. During the rainy season in high rainfall years larger areas of dambos have high moisture levels and this enhances crop production in the marginal dambo, compensating for decreased production in those dambo areas that waterlog under such wet conditions. The intercropped rice and maize system described above further stabilises crop yields under variable rainfall. However, dry season gardening does benefit from high rainfall in the previous wet season.

The grazing value of dambos is also somewhat stabilised in the face of rainfall variability. High rainfall increases the amount of residual moisture from the previous wet season, and water infiltration into dambos during the dry season, so elevating dry season fodder production. However, excess moisture reduces the palatability of the existing species of grasses (due to shifts in the balance of water and nutrients: 3.2.1; and the denitrification effects of waterlogging). Furthermore there will also be shifts in species composition towards sedges which are less favoured by cattle (Theisen, 1976a:6). Such effects will be driven by the rainfall 'cycle' of wet and dry decades (3.1.2). In wet years there is also more churning of the mud by stock and physical damage to plants (cf. Acres *et al.* 1985:82-3).

It has been established above that dambos maintain greater stability of production because their moisture content varies less than topland, and secondly because what variation exists in moisture results in less variation in crop and grass yields. The third way in which dambos stabilise the system is through the fact that even if what is produced in extreme years (particularly droughts) is somewhat less, it is **economically** more valuable. In this sense they act as a 'key resource'.[60] The opportunity cost on the fodder they provide to livestock during the late dry season and at times of severe drought is very high, and the economic benefits of farmers through herd survival at these critical times considerable. Crops produced in the dambos in droughts years are important for food security and have an open market value higher than the normal and official prices (see also Drinkwater, 1989a).

IMPLICATIONS OF HETEROGENEITY:

Part B: Higher Spatial Heterogeneity and Species Diversity on Sandveld

This section continues the theme that sandveld environment is a more heterogeneous one than clayveld and hence shows less seasonal and inter-annual variability of production. Additional dimensions to catenal development (3.3.3) and factors driving spatial variablity in soil nutrient status (3.3.4) are discussed together with farmer strategies to exploit this variability. Section 3.3.5 examines how the heterogeneity (and possibly low nutrient status: cf. 3.2.1) of sandveld results in a much higher species diversity in this zone. This in turn effects hunting and gathering. Finally Section 3.3.6 identifies the ecological factors that lead sandveld to support large baboon populations, and draws attention to the problems that this causes.

3.3.3 Additional dimensions to catenal development and land use strategies

Kopjes (Broken Hills)

Sandveld areas in the middle and lower veld in the central south are generally ancient plateau outliers (Lister, 1979; Cole, 1982:146-7). This means that they are associated with patches of broken granite hills (kopjes: **makomo**). These add a further dimension to typical catenas in this zone. Kopjes support a rather distinct tree and herbaceous-layer flora (Higgs, 1987; Wilson, 1987d). Soils are typically shallow but are very variable in depth. Deep litter may accumulate in patches amongst the bare rocks and such soils are generally 'fertile'. The kopjes thus provide a range of micro-environments. Some places may be very wet during the rainy season due to concentrated run-off; but these have a tendency to also dry out more rapidly between rain falls and in the dry season. On the whole the productivity dynamics of the kopje areas therefore rather resemble that of the eutrophic clayveld system. They thus show more variable production in the face of rainfall variability, and relatively high forage values in the dry season. They are important areas for grazing livestock during the wet season, as they are separate from cropped areas, which makes herding easier. It is currently illegal to farm the small patches of fertile soil within the kopjes, and only one farmer in the sample practises this on a large scale. In the past this was a favoured low input agricultural method (Appendix Two). Kopjes provide areas of little disturbed woodland which is valuable for its tree products (construction material, fuel, fruits, edible insects, etc.) and as a hunting and gathering resource (Appendix One).

There are kopjes in the clayveld zone, but they are much smaller and less common. Nevertheless they do provide micro-environments for tree and herb species (Higgs, 1987; Wilson, 1987d). The importance of this is shown in the effects on diversity on gathered plants in Appendix One. The contrast between the productivity dynamics and herbage quality of the kopjes and the flat lands in the clayveld is much less marked than that in the sandveld. Though they are used in the same way as described for sandveld above, they are much less important, both because of their small area and because of their properties.

Sodic Clay Soil Patches

Patches of dispersed clays (**zvimhamhare**) are common both within sandveld and clayveld in the study area. A suite of related explanations for their formation in different topographical sequences have been offered (Nyamapfene, 1986b; Dye and Walker, 1980; and Stocking, 1979). Basically sodium derived from the weathering of feldspars accumulates in sites of impeded drainage where it disperses the high clay mineral content.[61] This means that moisture can rarely penetrate deeply and soil moisture status tends to alternate in an extreme fashion; this limits the potential for plant growth and roots are confined to the surface layer.[62] The dominant tree species is *Colophospermum mopane* (as elsewhere Dye and Walker, 1980; Nyamapfene, 1983, 1986b:48) and there is a sparse cover of grasses (Dye and Walker, 1980). Although herbaceous layer biomass is very low, these grasses are highly palatable and these areas provide favoured grazing, as they do for wildlife (Child, 1989). There are frequently bands of extremely salty material within these sodic clay patches, called **bare** in this area. These are used as a mineral lick by stock, and were once used by people for salt manufacture. They are not cultivated in Mazvihwa.[63]

Although sodic clay soil patches are more common and extreme within the clayveld zone, the contrast between their vegetation and ecological conditions and the surrounding area is more marked in sandveld. Therefore they contribute greater heterogeneity to sandveld.

Drainage Lines and River Banks

Drainage lines (**makwatara**) are defined as naturally wooded areas where water flows during storms, without channel development. These are narrow strips located at right angles to most slopes, generally connecting with dambo or stream systems at their base. They occupy a larger area in the clayveld zone, due to greater surface run-off on these soils and because areas that might be drainage lines in clayveld develop as dambos in sandveld due to ground water seepage.

The contrast in plant growth between the drainage lines and surrounding topland is more marked in the clayveld zone, presumably because clayveld productivity is more constrained by moisture than is that of sandveld. The difference between topland and drainage lines is greatest in drought years.[64] Plant growth in drainage lines is restricted to the wet season, though it may continue for a short time afterwards using residual soil moisture, as there is little seepage into these areas.

Drainage lines on clayveld have sometimes been considered favoured agricultural sites in the past due to the influx of additional water. The imposition of the Native Land Husbandry Act (1951) in the early 1960s ended the common farming of drainage lines in Mazvihwa on the grounds of soil erosion control (Wilson, 1989b).

The banks of the Lundi and other, smaller, rivers in the study region are an important resource. They generally lie in the clayveld system because it is these younger soils that lie on the lower, newer, land surfaces (Lister, 1979; Cole, 1982). Except at a few sites, the rivers are bordered by steep terraces of several metres height which are never breached by floods.[65] These fringing floodplain areas were the favoured farming areas during the original settlement of the area, but this was suppressed in the 1930s and 1940s (Appendix Two; Wilson, 1986b, 1989b). Apart from these low lying areas the extent of land that receives the benefits of river water to boost herbaceous layer production is much less than that for the fringe of trees tapping the groundwater. From the point of view of grazing, the main current land use, I would therefore define the riverine zone more narrowly than does Scoones.[66] During the rainy season there is elevated plant production on river banks due to extra moisture, and new grass also grows in the dry season on the parts of river banks low enough to enable grass roots to tap river water.[67]

Scoones' (1988a: figures 2-4) one day/month monitoring of foraging behaviour by a herd in clayveld illustrates the importance of the drainage lines and river banks for grazing. During the rains and the late dry season cattle spent around two thirds of their time in these zones, and one quarter in the early dry season.[68]

The ground water supplies of the drainage lines, and especially the riverine zone and the micro-environments created by there by rocky slopes and boulders provide opportunity for many tree species otherwise absent or restricted to sandveld.[69] Such trees tend to show sandveld productivity dynamics, by coming into leaf and fruiting in the dry season.

Drainage lines and river banks thus have a somewhat stabilising influence on the clayveld system, but are of rather less importance in sandveld.

3.3.4 Spatial Variability in Soil Nutrient Status

This section examines how biological processes create spatial variability in nutrient status. Since nutrient shortages are a critical constraint on sandveld productivity (cf. 3.2.1), the effect of this variability is likely to be more marked upon sandveld. These highly productive sites ('hot spots')[70] within sandveld can be expected to show enhanced productivity variability in response to rainfall variation. Yet to the extent that lateral concentration of clays and nutrients is responsible for the elevated status of the 'hot spots' there may be no increase in the variability of primary production of the system as a whole, as gains in variability at the site will be compensated by declines in such variability in the surrounding area from which the nutrients and clays are derived. However, vertical concentration is also significant and the effects of this on primary production variability could be considerable.

Despite the fact that under natural vegetation the effect of nutrient hotspots is to enhance the variability of production under variable rainfall, within an agro-ecosystem they can actually be used by farmers to stabilise production through differential planting.

The three principle biological processes creating this variability in nutrient status on sandveld are the effect of trees, termitaria and old homestead sites.

Effect of Trees

It is now well established that trees concentrate nutrients vertically and laterally leading to nutrient-rich micro-climates around their bases, and that in addition to this that some fix nitrogen.[71] Development of woodland at a site enriches the soil in that patch.[72] This enhanced fertility may then be lost subsequently through disturbance following tree removal (eg. during cultivation), but some aspects of nutrient concentration can be surprisingly persistent in some situations.[73]

Litter also plays an important role in enhancing rainfall infiltration. However, trees tend to reduce soil moisture under them to some extent by interception of rain and by root competition, but also reduce evapo-transpiration through shading. The effects of different tree species in different topographic circumstances and land-use systems will therefore tend to vary; as will the effects on different herb and/or crop species.[74] On the whole, however, the effect of trees is most marked in the sandveld areas, due to the fact that plant-available nutrients are much more of a critical constraint to the productivity of sandveld soils (see Section 3.2.1).

A pilot study of the effects of three of the most common species of tree found in sandveld fields was conducted in Mukotose, Chivi, in January and February 1987.[75] Those results available from this study, are presented in Table 3.3.4.1. *Parinari curatellifolia* raises soil organic matter, nitrates and particularly (relatively immobile) phosphate status beneath it, and it is suggested that *Ficus* spp. has similar effects.

It has been established theoretically that those trees with what is termed 'low quality' litters (ie. that break down most slowly) increase soil organic matter the most and lead to the greatest extension of the time period of nutrient availability to growing plants (Swift, 1985 and Prinsley and Swift, 1986). It turns out that *P. curatellifolia* actually had the slowest rate of litter breakdown of all miombo trees covered by the research of Malaisse *et al.* 1975:144.

This pilot study cannot report the availability of these nutrients through the growing season as the soil samples were taken just before harvest. The interaction between different nutrients and water as constraints to crop growth (at different stages) in these Chivi fields is unknown.

Soil moisture content was everywhere very low, as this was a marked drought year (c. 280mm rainfall), and the samples were taken a month after substantial rains had fallen. *Ficus sur*, in particular, gives the impression of notably raising soil moisture status during the rainy season.

These soil nutrient and moisture results have been confirmed by a follow-up study conducted by the Commonwealth Science Council Agro-Forestry Research and Training Project in the neighbouring District of Shurugwe (Julie Ingram pers. comm. 1988).

Recognizing the beneficial effects of certain trees upon soils, and their value as trees, farmers have preserved and planted favoured tree species within their fields.[76]

Trees have been left in fields for as far as records go back (seventeenth century Portuguese sources), but the role that the trees have played in the agro-ecological system has been changing dramatically (Wilson, 1989a). Crop yields are generally higher beneath trees, and this is especially apparent in the fields of those farmers too poor to make nutrient inputs.[77] However, calculations of tree densities and the area each tree effects shows that the increases in yields at field level are minor because the area of the field involved (1 to 5%) is too small to make major overall impact at current tree densities (Wilson, 1987d:75).

TABLE 3,3,4,1 SOIL ASSESSMENTS UNDER AND OUTSIDE OF TREES IN FIELDS

	Parinari curatellifolia					*Ficus sur*					*Ficus stuhlmanii*				
	n tree	n samp	mean	s,d	Prob	n tree	n samp	mean	s,d	Prob	n tree	n samp	mean	s,d	Prob
SOIL MOISTURE															
Under tree	2	6	3,51	1,67	n,s,	2	6	2,19	1,17	<0,1	2	6	2,93	0,81	n,s,
Outside tree	2	6	3,12	1,88		2	6	1,24	0,46	n,s,	2	6	2,72	0,93	
ORGANIC MATTER[1]															
Under tree	2	6	1,62	0,26	<0,0005	2	6	0,95	0,13	n,s,	2	6	1,23	0,42	<0,25
Outside tree	2	6	0,76	0,30		2	6	0,92	0,18		2	6	1,04	0,14	n,s,
pH															
Under tree	2	6	6,03	0,17	<0,1	2	6	6,39	0,64	<0,25	2	6	6,48	0,54	n,s,
Outside tree	2	6	6,19	0,16	n,s,	2	6	5,88	0,92	n,s,	2	6	6,47	0,81	
NITRATE[2]															
Under tree	7	21	0,92	0,42	<0,025										
Outside tree	7	21	0,68	0,32											
PHOSPHATE															
Under tree	7	21	47,7	42,8	<0,0005										
Outside tree	7	21	10,4	14,7											

Notes to 3,3,4,1
Soil samples were taken from 15cms depth, and from three points within $1m^2$ for each sample.

Soil moisture is expressed as a percentage
Organic matter is expressed as a percentage
Nitrate (NO_3) is at parts per thousand
Phosphate (P_2O_3) as parts per million

1. Organic matter content was obtained by combustion
2. Nitrate levels refer only to those pre-incubation. Total N was obtained but the result has not been conveyed to me to date.
   Pre and post-incubation nitrate levels were also assessed for the *Ficus* trees but the results have not yet been communicated to me.

Farmers tend to treat the land beneath the trees in fields rather differently than that of the rest of the field. Occasionally a different crop is planted - most frequently maize - in order to take advantage of the elevated fertility. More commonly farmers apply manure and other fertility inputs only in the main field as the soil beneath the tree is deemed as already having adequate fertility. Extra weeding is usually required under trees due to the improved plant-growth conditions. Replanting is also more commonly necessary due both to poorer planting,[78] in these areas because of disrupted ploughing, and also higher risks of trampling by people resting in the fields.

The importance of trees in fields for nutrient benefits in sandveld areas is shown by the fact that densities of trees in fields on these soils were two to three times those on clayveld in a number of surveys in Mazvihwa.[79] This also reflects a higher density of fruit trees upon the sandveld and thus additional reasons to preserve the trees. 98% of the trees in fields on sandveld in the Chivi and Mazvihwa samples were fruit trees, whereas on the heavy soils in Mazvihwa only 33% of the trees were fruit-bearing. Upon clayveld the negative effects of trees upon soil moisture, and the lack of a requirement for nutrient elevation, makes preserving trees a less attractive proposition. A very low density is preserved on Mazvihwa clayveld (c. 1/hectare), just sufficient to provide the necessary shade trees together with 0.2 *Sclerocarya birrea* fruit trees per hectare.

Leaf litter beneath trees outside of field areas for application to fields is also viewed as a valuable resource by many farmers in the nutrient deficient sandveld. This litter may be applied directly to the fields or placed within the cattle kraals to mix with the dung to bulk up manure. The use of such leaf litter was found to be more common in higher rainfall areas and in non-dambo lands on other field trips (eg. Chivi, Mhondoro and Chinhamora)[80] regions where nutrient deficits are more marked than in Mazvihwa sandveld.

Termitaria

Macrotermes termites 'transport large volumes of mineral and organic matter, both vertically and laterally, and the mounds tend to have higher clay content, less coarse sand, higher pH, carbon, nitrogen and bases (especially calcium)' (White, 1983:27-8). There is indeed a large African literature on the composition of termite mounds in relation to the surrounding soil.[81] I contend that the difference between the soil in termite mounds and surrounding soil is greater in sandveld than clayveld. Sandveld soils show considerable vertical differentiation in clay content, and termites transport up the clays from the subsoils to produce the mounds.[82] However, although the differences are less on clayveld there still remain some differences between termitaria and surrounding soils especially in cations, and in the drier regions (Watson, 1975).

The effect of termite mounds on the dynamics of primary productivity can be understood by considering the interaction of moisture and nutrients as constraints to plant growth (ie. the principles identified in 3.2.1). As they are rich in clay the mounds 'tend to [have] lower productivity when the water availability is low and to increase productivity when water availability is high. This is observed along a climatic gradient as well as on one site experiencing variable rainfall' (Menaut *et al.* 1985:23). The impact of mounds on the sandveld system as a whole is therefore to increase variability in production.

Farmers exploit termite mounds to increase crop production, and do it in such a way as to limit the increasing variability in yields that is expected on ecological grounds. Differential use of termitaria by tropical agriculturalists is very marked and has been frequently noted in the literature.[83] In Zimbabwe a variety of crops have been noted as preferentially planted atop termitaria, especially a slightly late planted maize, and higher yields are achieved on these sites (Nyampfene, 1986a). In the study area, however, there is little planting on top of mounds compared to the high rainfall regions, because the heavy soils of the steep and elevated mounds do not manage to yield well in most years in these dry areas. Where a special crop is planted on the mound it tends to be one tolerant of low moisture (such as sorghum) rather than a high moisture-requirer like maize which is grown in wetter regions. Rather than plant on mounds, farmers excavate the mounds and spread the soil over the sandy soil of the field.[84] By spreading the clay-rich soil over the fields the pH, nutrient, water retaining and CEC advantages are achieved without much enhanced moisture stress, and without much increase in the variability of yields with rainfall. Theisen (1976) and Watson (1977) have empirically demonstrated the benefits of termitaria soil use in this manner in peasant agriculture in Zimbabwe. There is no mention of termite mounds in agricultural extension. Whilst some Agricultural Extension officers are against it, seeing it as backward traditionalism, there are others who support and even encourage termitaria soil use.

Termitaria soils are not applied to fields on clayveld because these soils will not benefit from further enhancement of clay and mineral content.

Homestead Sites, Home Fields and Old Home Fields

Homestead sites tend to accumulate both clay and nutrients. Clay is brought in for the construction of floors, the mudding of walls and for the making of bricks.[85] Nutrients are concentrated at the site through decaying building timbers and thatching grass, domestic waste, ash from cooking and heating fires, dung and droppings of livestock and chickens, and human excreta.[86] Surprisingly, there appears no quantitative literature on the effect on homesteads on soils in Africa. However, a remarkable study by Hall (1984) has shown how prehistoric homestead sites in the Mfolozi and Hluhluwe valleys in South Africa are still floristically different due to the persistent effects of this elevated soil fertility. The mechanism by which such nutrient hotspots maintain their status can be appreciated, in part, through reference to studies of ungulate use of such areas. Belsky (1986) explains the *Chloris-Andropogon* mosaic in the Serengeti as being the result of an original heterogeneity in soil surface topography and sodicity of these volcanic soils that has been enhanced and stabilised by the effect of differential ungulate use. Patches with higher nutrient status and productivity are more heavily consumed, trampled and dung-enriched. These can maintain their status and vegetation through the importation of nutrients, the prevention of leaching through trampling (compaction), and more rapid nutrient cycles within them. A similar effect occurs at old boma (cattle holding) sites on the Athi Plains in Kenya (Stelfox, 1986). Tolsma *et al.* (1987) have described how boreholes lead to build up of nutrients through the attraction of stock for watering. This leads to improvement of the nutrient status of the plants at the site, and there are also changes in vegetation composition.[87]

Home fields play an important role in many African farming systems; typically being managed on a more intensive basis than the out-fields. In nutrient-poor regions of Africa they have tended to increase in importance where general depletion of soil fertility is occurring. This is because farmers find it much easier to apply nutrient inputs, such as manure, to fields close to the home, and because human refuse, etc., adds a natural 'fertilizer' to those sites. In Zimbabwe the government has generally opposed the development of home field cultivation because of the notion that arable and grazing land should be kept separate and a straight line of households used to divide them. However, home fields have become important, even dominant, in the economies of some areas (eg. in Chirumhanzu, Drinkwater, 1989a).

It is predicted that in this study area that home fields would be more important in the nutrient deficient sandveld than in the clayveld. This is supported by the quantitative data. In the sandveld proper all the households have home fields; these actually merge with the so-called out-fields. This does also reflect the fact that due to historical factors the population in this zone has been much freer to settle where it would like, and have therefore made their homes near their fields for general convenience and to aid the guarding against baboons. The proportion of home fields held by the boundary population and clayveld samples can be compared more independently. Whereas in the boundary population 12% of the arable land held was home fields, this proportion was only 3% in clayveld. Detailed examination of how arable land was obtained through collecting life-histories in the two populations identified the strategies used for obtaining home fields. Boundary populations, nearly all of whom actually have their homesteads upon sandveld, have frequently used house rotation to establish large home fields. After enclosing and farming a small area around their home they move the house a short distance, cultivate the old site and continue to use the land they used to farm around it, opening a further area at the new homestead site. Community and government have failed to expell people from these areas in part because there remains a very strong sense of the right to people to farm their old homestead areas.

3.3.5 Species Diversity in Sandveld and Clayveld

Dystrophic sandveld systems are believed to be much more species rich than those of eutrophic clayveld, with up to twice as many species per unit area (Frost *et al.* 1986:26). Much higher diversity in woody plants in sandveld was shown in Mazvihwa with quantitative surveys of quadrats by Higgs (1987; and pers. comm. 1987) and in total species lists (Wilson, 1987d). Frost *et al.* (1986:26) advance two related hypotheses in explanation of this: first that with lower nutrient status status competitive equilibria may take longer to reach; second, that there might be greater potential for stable coexistence given a higher specialisation by species to capture nutrients in the array of microsites available. The latter hypothesis could be extended, on the base of the additional factors creating heterogeneity on sandveld noted in 3.3.4.

Diversity begets diversity as plants - especially trees - create micro-environments and food sources for other plants and animals.

Diversity of Hunted, Fished and Gathered Resources

The higher diversity of sandveld is reflected in the wider range of wild resources that can be hunted and gathered in that zone. This is illustrated below by documenting edible species diversity in the two zones, using the data presented in Appendix One.

Amongst Lepidopteran larvae (caterpillars) three ethno-species were found in both zones and seven in sandveld. None were restricted to clayveld. Of the other ethnospecies of insect consumed, nine were found only on sandveld, and only one was restricted to clayveld; nine were found in both zones.

Twenty-seven fruit trees are restricted to sandveld, twenty-one can be found in both ecological zones, and only two are restricted to the clayveld. Of other edible plants, forty one are restricted to sandveld, twenty to clayveld and twenty can be found in both zones. Forty-four ethnospecies of edible fungi were found only on sandveld, whilst only four species were recorded as restricted to clayveld and just three were found in both zones.

However, though there were ecological zone preferences in about half the edible mammals recorded as hunted, and there was a slightly higher diversity in the sandveld zone, these differences were marginal. Six edible mammal species were reported by locals to occur only in clayveld, whilst there were eight found only in sandveld. Seventeen edible species (mostly rodents, lagomorphs and carnivores) were reported to exist in both zones.

3.3.6 Competition with Baboons in the Sandveld Zone

A notable feature of the sandveld zone in this region is the presence of large populations of baboons. This is related to several of the ecological features of this zone which have been discussed above.[88] The structural heterogeneity of the sandveld provides the sleeping refuges (**zviro**) for the baboons within the kopjes (3.3.3). Equally important is the presence of the fruit trees of the miombo system (3.3.5 and Appendix One), and the fact that they fruit throughout the year (partly due to the availability of ground water, 3.2.1 and 3.3.1). Fruit is particularly important during the off-season for crop raiding (between the completion of crop harvest in May-July and the first ripening of crops in late January). Wild fruit also helps baboon populations to tide over the years of poor crop harvest, when farmers are quick to reap what little they get.

Baboons are an extremely serious pest within sandveld. They steal and damage a considerable proportion of crops, kill and eat many goats, even raid homesteads, and require enormous investments in guarding labour.[89] Women argued that the time women and children spend guarding against baboons, combined with adverse disease environment, seasonal labour, and food shortages, cause the poor wet season nutritional status that is characteristic of this zone but not clayveld (Chapter Five).

3.3.7 Conclusions

Section 3.3 has enumerated further contrasts between the sandveld and clayveld environments. The permeability of sandveld soils mean that there is much more groundwater availability in this zone, and this seeps out into dambo wetlands. Sandveld catenas generally show more marked development than do those of clayveld, and sandveld systems also show greater spatial variability in soil nutrient status due to the effects of trees, termites and human settlement. This sandveld heterogeneity enables farmers to achieve some stabilisation of production in sandveld in contrast to clayveld, and enhances the differences already established in Section 3.2. The variability of sandveld increases species diversity and so makes available a wider variety of resources to be hunted and gathered. These conditions also provide suitable habitat for baboons, which are a major agricultural pest.

Chapters Four, Five and Seven now examine how this difference in production dynamics affects food supply, anthropometric status, and demographic processes in the two populations. Prior to this examination of welfare data, a short discussion of farmer strategies and responses to rainfall and production variability is required (Section 3.4). The ecological differences discussed in this section, principally the presence of seasonal swamps in sandveld, also have marked implications for seasonal and inter-annual disease environments. These are addressed in Chapter Six.

3.4 Agro-Ecological Strategies in the face of Rainfall Variability

3.4.1 Farmer Responses to Contrasting Ecological Dynamics

This section briefly examines the responses of farmers to the contrasting ecological dynamics of the two zones. Within clayveld farmers focus upon utilising available soil moisture, whilst on sandveld the nutrient constraint is addressed by making fertility inputs and exploiting environmental heterogeneity. In addition to patterning the use of each ecological zone in accordance with its dynamics, people also switch between the zones on a seasonal and inter-annual basis that responds to their contrasting variability.

Nutrients versus Moisture as Constraints addressed by the Farming Systems

Sections 3.2 and 3.3 suggest that different orientations are required for farming systems in the sandveld and clayveld zones. Successful farming in the sandveld system requires tackling the nutrient constraint (Grant, 1981). There are two broad ways in which this can be done: exploiting the natural heterogeneity in soil fertility, and, second manipulating nutrient cycles to concentrate nutrients in fields (Swift *et al.* 1988).

The main nutrient cycle intervention in sandveld is to apply livestock manure to fields. These nutrients have been obtained from the grazing area and are thus concentrated on an arable patch (cf. Floyd, 1964:303-4; Theisen and Marasha, 1974:47; Swift *et al.*, 1988). Termitaria soil and leaf litter (and occasionally compost) are also applied, these both raise nutrient status, but also (and importantly) improve the soil's capacity to retain nutrients and make them available to plants over a longer period (Swift *et al.* 1988). Since carts and draught power are required to transport significant quantities of termitaria soil and leaf litter, all major nutrient cycle interventions in sandveld are dependent upon livestock access. Inorganic fertilizer is only very rarely used in the study area for economic reasons.[30] Draught power is also important upon sandveld as timely planting is required to establish plant growth in time to exploit the nutrient flush, as well as within the short rainy season. Dambo agriculture is critically dependent on planting at the right time relative to seasonal flooding.

Within the clayveld zone the ability to get extensive areas under crops rapidly to exploit potential rainfall is most critical. This requires draught power access (mainly cattle; also donkeys). Draught power is used to winter-plough land to enable dry planting and high infiltration during the early rains, and to plough extensive field areas soon after the first heavy rains. Within the clayveld zone, manure and other fertility inputs are only used within irrigated land and gardens, as on these heavy soils as nutrients are not an important constraint.

Access to livestock is therefore critically important for production in both zones (Wilson, 1985b; Scoones and Wilson, 1988), as it is elsewhere in Zimbabwe; (Danckwerts, 1974; Collinson *et al.*, 1982; Sandford, 1982; Farming Systems Research Unit, 1984; Shumba, 1984; Mudimu, 1983; Mombeshora, (undated c.1985); Cousins, 1988). In Chapter Four quantitative effects on food production of access to livestock are demonstrated.

Farming system strategies toward tackling these different constraints are shown to be highly dependent upon historical factors. These condition economic factors that affect the response to trade-offs between productivity and variability, control the variety of farming tactics available technologically and impose socio-political constraints upon land-use. Marked historical changes in the agro-ecological systems in the study area are reviewed in some detail in Appendix Two. Farmer tactics in the face of rainfall variability within the current cropping system are examined in more detail in Section 3.4.2 below.

Switching Between Ecological Zones as an Ecological Strategy

As the seasonal and inter-annual productivity dynamics of the sandveld and clayveld ecological zones are different the populations of the zones would be predicted to switch their use of the two zones accordingly. Throughout southern Africa there is ethnographic evidence that the contrast between the clay and sandveld soils and the ecological systems that they support is well known by farmers and herders who thus do use it to construct their land-use systems.[91]

The seasonal migrations of stock between the ecological zones has been a feature of many cattle keeping societies in Southern Africa.[92] The clayveld was used during the dry season as the annual grasses on the more fertile soils maintained higher dry season nutrient content. The reasons for the abandonment of this system in the study area include the military destruction of the political system that organised it (through the wars with the white settlers in 1893 and 1896), the break up of contiguous land areas by the establishment of white farms, the imposition of veterinary movement regulations, shortages of herding labour due to urban migration (cf. Arntzen 1984:106), and finally changes in the relative ecological advantages of migration in more heavily grazed systems. Whereas stock once moved into the Mazvihwa clayveld during the dry season seeking quality forage, they now move in the opposite direction, especially when there is drought (cf. Scoones, 1987). This in part reflects increases in sandveld forage quality under heavy grazing (cf. Bell, 1981 and 1982), but is largely due to lack of sufficient grass production in clayveld during drought years for the larger herds. This has led to increasing intense migrations out of clayveld into sandveld in drought years (Wilson, 1985b:76; Scoones, 1987).

Rural Shona articulate the contrast between the two ecological zones as a basic foundation to indigenous ecological knowledge. This has also been recorded by other researchers, despite the fact that most of these workers were themselves unable to understand the ecological reality behind the belief system.[93] Since people recognized the value of having access to both ecological zones, the first part of Mazvihwa settled after the end of hill-top living (see Appendix Two) was the boundary between the sand and clayveld. Even today, and despite disruption by agricultural planners, the population in this boundary zone has maintained its fields as neatly divided between those on the sandveld and those on clayveld. Similar situations of 'land fragmentation' onto soils of different types exist in many areas of the world conferring clear advantages (Bentley, 1987). For example, Pedi farmers in South Africa, are particularly anxious to farm both heavy and sandy soils so as to manage inter-annual variability in rainfall.[94]

The populations on each soil type make expeditions to gather food from the other ecological zone when the season/year is right (see Appendix One and

Chapter Four). Once again the proximity of the boundary population means that they are in a particularly privileged position to do this. Tables 3.4.1.1 and 3.4.1.2 illustrate one resource for which quantitative data exists: firewood store species composition. It should be noted, however, that this data does not demonstrate collection strategies responding to different dynamics, simply that resources used are different between zones, and that the boundary population utilizes both.

Table 3.4.1.1 Composition of Firewood Stores in Three Ecological Zones

Population	Number Firewood Sticks Enumerated		Number of Species		Proportion Top Three Spp		Proportion Found Dead	
	1986	1987	1986	1987	1986	1987	1986	1987
Sandveld	884	5731	8	18	78	92	100	92
Boundary	2185	4536	30	28	63	63	87	96
Clayveld	4835	14948	13	26	88	91	48	90

Notes to Table 3.4.1.1:
Source: summarised from K.B. Wilson (1988) 'A review of the Mazvihwa firewood store data from 1986 and 1987', a report for Enda-Zimbabwe. Data collected by B.M. Chakavanda and P. Ndumo.

Table 3.4.1.2 Top Firewood Species in Stores By Ecological Zone (1987)

Species	Sandveld %	Boundary %	Clayveld %
Brachystegia glaucescens	40.1	6.4	0
Julbernardia globiflora	18.8	2.5	0
Mubaribari	31.6	4.5	0
Grewia spp.	0.2	9.8	0.2
Colophospermum mopane	0	10.6	30.8
Combretum apiculatum	3.8	23.7	20.0
Acacia nilotica and *A. tortilis*	0	3.4	39.9
Combretum imberbe	0	0.9	4.2

Notes to Table 3.4.1.2:
A dictionary I have drawn up of local and scientific tree names is found in Appendix Three.

Percentages are of the proportion of total firewood store sticks (including those species not listed here) made up by that species. Information about the numbers of stores and sticks is presented in Table 3.4.1.1.

Source: summarised from K.B. Wilson (1988) 'A review of the Mazvihwa firewood store data from 1986 and 1987', a report for Enda-Zimbabwe. Data collected by P. Ndumo.

Some caution is required in interpreting the firewood store data because the sample sizes for each ecological zone and year are different. Furthermore there was a marked change in firewood use between 1986 and 1987 due to the adoption of a community rule against the cutting of live trees for firewood (Wilson, 1988). Generally speaking, however, the data in 3.4.1.1 suggest that the boundary population exploits a wider species diversity of trees than do either clayveld or sandveld populations. From the species composition data (Table 3.4.1.2) it is clear that the reason for this is that the boundary population is gathering firewood from both zones. This use of a wider diversity of trees is responsible for the fact that the top three species comprise a lower proportion of total firewood used in this boundary population than those on sandveld or clayveld.[95]

Tree fruits, edible fungi, caterpillars, and other resources from both zones are also more available to the boundary population. Nevertheless I found that some people in both clay and sandveld were prepared to trek right into the other zone for certain resources at certain times (see Appendix One and Chapter Four, Section 4.3).

Not only does the boundary population use the resources from both zones, they also exhibit broad seasonal shifts in line with the contrasting production seasonalities shown by the two soil types. For example it was in the dry season and in drought years that the boundary population (and to a small extent those from clayveld) especially came into the sandveld woodlands to seek for the wild fruits (Chapter Four, Section 4.3.5).

Systematic exchange occurs between the populations in the two ecological zones although the intensity of this has declined with integration into the national economy. During dry years the clayveld population barters ('**kushuzha**') assets (principally livestock) for food with sandveld populations, especially those in areas where there are large areas of dambos (Wilson, 1986d and 1987a). In the wetter years livestock reproduction on clayveld is rapid and this compensates for this trade (Wilson, 1986a, 1986b). Since marriage is dependent upon large bridewealth payments, Chapter Seven examines data to suggest that marriage rates also respond to rainfall levels in the two zones. Indeed until the 1950s there was a direct exchange of young girls for food during famines (Wilson, 1986b and 1986d; see Appendix Two). Since the populations of the two zones have extensive social ties there is also movement of individuals - mostly children and old women - to join households in whichever ecological zone is being favoured by the level of rainfall. (Chapter Four, Section 4.1.)

3.4.2 Food Production Strategies and Rainfall Variability

Avoidance, Resistance and Tolerance of Primary Production Variability: An Overview

Due to their basic dependence upon settled agriculture Southern Shona have never had much opportunity to 'avoid' drought through regular migration. Migration associated with drought in Zimbabwe has tended to be a last ditch survival strategy. However, there has been increasingly important migration with cattle in search of grazing (cf. Wilson, 1985b:76; Scoones 1987).

Avoidance of drought became significant only as people became less dependent on agro-pastoralism (and thus less vulnerable to rainfall variability) through involvement in wage labour in the mining and urban economy. Since the early years of the century drought has characteristically raised the number of men seeking work on local labour markets (Zachrisson, 1978; Holland, 1987 and Iliffe, 1989). In addition to migrant labour being an avoidance-response, the simple fact that about half the men are involved in such labour lessens the degree to which most homes are vulnerable to agricultural production variations.[96]

Wage labour has also tended to be seasonal, whereby men preferentially worked during the dry season so as to be able to contribute to agriculture in the rainy season (Johnson, 1968); but this has declined in recent years due to a general stabilisation and formalisation of work contracts.

The rural labour, trade and craft market also contributes significantly to income (Adams, 1987, 1988; Wilson, 1987e). But it does not markedly stabilise income because purchasing households are also under greater economic stress at the times in question. Though certain of the wealthiest households preferentially employ people at such times, and benefit through paying lower than usual rates, any such increase in employment is insufficient to balance the general drop in demand and so prevent a trend to reduced income.

The distribution of food relief has contributed to stabilising food supply, especially in the 1982-4 and 1987 periods. The reception of this food-aid has not been a passive process: rather considerable peasant organization has put pressure on nationalist politicians to meet the food deficits of drought years. As such it should also be included as a peasant strategy.

'Resistance' to variation in rainfall is most easily practiced in the heterogenous sandveld through the exploitation of dambos whose productivity varies less than the rainfall (Section 3.3.2). Similar strategies for manipulating catenal variation to stabilise production have been described in Sierra Leone by Richards (1986). A second set of tactics are agronomic techniques that reduce the effect of rainfall variabity on yields; these include staggered planting dates, inter-cropping, the use of several soil-crop associations, and the use of varieties that can cope - and exploit - variable rainfall (see below).

One of the most important 'resistance' strategies is the use of large and well constructed granaries where several years' grain supply can be stored. Strategies for storage must be combined with crop choice decisions, as the storability of crops varies; see below. Farmers also accumulate assets (especially livestock) that can be exchanged for grain in drought (see Appendix Two). Finally resistance to grain deficit is achieved through social exchange mechanisms whereby richer farmers assist the poorer, and people provide mutual assistance. Loans are made on a no interest basis, including with grain traders, and defaulting is frequent and rarely tackled through the courts. Interest is culturally inconceivable on this type of loan.[98] Dependent and patrilinearly subordinate poor people are usually able to obtain free grain from their patrons, though this tends to bind them further into labour obligations in subsequent years.

'Tolerance' to variability in crop production has two components. First non-food expenditures are cut back in years following poor production. This is done both because grain sales are a significant income source and also because reductions in other purchases enables available money to be focussed upon meeting food needs. This 'tolerance' involves reductions in the purchase of clothes and other requirements when income is very constrained, but purchase of many items (especially of a capital nature) when the rains have been good. Some of these reductions in purchases are sufficient to compromise welfare, for example soap-use may be reduced in times of severe stress. The second component of 'tolerance' is reduction in food intake. Nutritional research indicates that certain nutrients can be stored in the body in sufficient quantities to cope with times of dearth (Harrison, 1988:27-8). Adaptation to energy shortage and protein deficiency can also occur (Harrison, 1988:28). However, the question of the degree to which such tolerance is used to 'cope' with variability is not specifically addressed in this thesis. I assume that such physiological capacities are relatively limited compared with the avoidance and resistance strategies outlined above.

Opportunism and Conservatism as Responses to Variability in Rainfall

African food acquisition strategies have been too often characterised as 'conservative', with this being said to be due to their living in 'harsh' environments. However, as the discussion of savannah ecological dynamics has stressed, the environment faced is not uniformly harsh but inherently variable with brief periods of tremendous productivity, especially in eutrophic environments like clayveld. This variability can be viewed as an opportunity as much as a constraint.

If the rainfall in the three years studied on the clayveld had been near average then the overall harvest over these three years in clayveld would have been only an estimated one third what it actually was.[99] This means that opportunistic tactics to capitalise on good years are required in order to achieve the conventional 'conservative' goal of food self-sufficiency.[100] Whereas researchers are writing about 'coping with drought' the situation faced by farmers is just as much 'how to capitalise on the high rainfall years'. The rich and poor categories of farmers in clayveld harvested equal amounts of grain per adult equivalent unit in the drought year 1986-7, while in the high rainfall year 1984-5 the richer households harvested 60% more grain, and were able to use this stored grain to cope with the drought in 1986-7 (see Chapter Four). Apparently most researchers seeking the explanations of changing (or rural differentiation in) famine vulnerability are sub-consciously convinced that they will find the answer in changes in production and exchange in the drought years. But drought years are not surprise events in the lives of the inhabitants of semi-arid regions; rather they are years nested within overall rainfall variation that includes bumper years also.

In contrast to clayveld, sandveld farmers can adopt tactics to enable them to stabilise production, through using dambo wetlands and other favoured resource patches (see Section 3.3). These stabilising strategies are still combined with a topland opportunism, even though the variations in yield on these toplands are not as extreme as in clayveld (see Section 3.2.1). If rainfall had been average all the three years monitored, the harvest would have been over fifty per cent of that achieved with variability.[101]

Crop Choice and Storage Strategies

Crop variety choice would be expected partly to reflect the problems of rainfall variability. The traditional approach of agronomists and anthropologists to this issue has been the prediction and conclusion that farmers tend to concentrate upon crops that yield relatively well at the lower end of the rainfall variability spectrum (ie. a 'safety first' type response). But empirical data on planting decisions and the yield responses of the varieties in question to back up this belief by researchers is lacking. In a study of the agronomic properties of indigenous crop varieties (Wilson, 1987b) I was struck that the dominant millet varieties were not the most drought resistant, but actually those that showed the best yield response over the whole range of rainfall levels. These characteristically showed properties considered 'weedy' (that is by agronomists!). They produced multiple small heads and had the best developed opportunistic tillering ability (for example **rushambo** bulrush millet and **chikumbo** finger millet).[102] This popular set of varieties do produce relatively well under drought conditions and this feature is welcomed by farmers, but it is a mistake to conclude that drought tolerance is the main reason they are grown. It leads to the erroneous assumption that if varieties that are higher yielding under low rainfall are developed and introduced (as is occurring in Zimbabwe as elsewhere) they will be welcomed and adopted by farmers. In fact many Southern Shona farmers have resisted such varieties. This is because they also require of their varieties that they yield exceptionally well in the high rainfall years; the years when most of their grain will be produced.

Variety choice is thus also subject to the complex relationship between opportunism and conservatism discussed above. Wealthier farmers can be predicted to heed risk less than the poor, and aim for maximum value production. In Zimbabwe the government has greatly limited fluctuations in the grain price, so that the value of drought year crops is not much greater than those in other years. This is a disincentive for aiming at relatively good production in drought years (and indeed to storage of crops by farmers for such years). Farmers do better to concentrate on elevating yield and sales in wetter years where the volume of the production dwarfs that in droughts (see Chapter Four).

Although quantitative data is not available it appears that a greater proportion of clayveld farmers grow highly opportunistic varieties than do the farmers of sandveld, especially in the case of finger millet. This is what would be predicted on the basis of ecological productivity dynamics.

Crop storage is important due to the high level of inter-annual variability in yields. The following discussion addresses trade-offs between yield potential, preparation-labour and storage losses, and their effect on farmer planting strategies. Bulrush millet and maize are the dominant cereals in the Mazvihwa area. Bulrush millet yields are higher in drought years, and probably higher overall because this is a very dry region. Furthermore bulrush millet is much more storable than maize or sorghum. It is therefore important to identify the reasons why millet is not grown more. Labour inputs into millet are higher,[103] and there is considerable vulnerability to bird pests.[104] But these explanations are not sufficient. Most of the population prefers the taste of millet sadza. Despite past biases in favour of maize, agricultural extension workers have been vigorously promoting millet in the last few years with minimal success. Even the land spirit 'mwari' has been calling on peasants to grow drought resistant millets during the 1980s (Mukamuri, 1989).

It was only through informal discussions with women that the reason for the popularity of maize became apparent. Maize can be ground direct at nearby hammer mills, whilst millet first requires considerable pounding to remove the husk. This labour is extremely unpopular with women as it is an almost daily chore requiring much time and energy. Despite the ideology of male-dominance in Zimbabwe, women have considerable (if variable) influence on crop choice, and therefore tend to choose maize rather than millet due to this preparation labour cost. Furthermore men are generally obliged to provide for food during times of shortfall from their own private assets, and this makes many women less risk aversive than men in this regard.

The outcome of the trade-off between male and female interests is affected by how much grain there is in store from previous years, as this influences risk. The oscillation that results I term a 'maize-millet cycle'. At a time of low cereal reserves female and male household members agree to give preference to growing millet. Over a period of years a store of millet will accumulate capable of providing security for times of crop shortfall. As the reserve accumulates women will successfully advocate for a larger and larger crop area under maize. In good years maize will be sold and consumed, and millet kept for further years, whilst in droughts the stored millet is eaten. Consumption of the bulrush millet in store leads to a reversion to growing millet, and so on. This cycle is evident in most households according to case history interviewing.[105] It also occurs on a regional level as high and low rainfall years have net effects on individual household level security. In recent years in Chivi the estimated areas under maize and millet were shown to display this cyclical pattern convincingly (Balderrama *et al.*, 1988:31-2).

Households of different economic status can be expected to show different degree of concentration upon maize and millet due to different perceptions of the risk factor. In adjacent Chivi middle-income famers grew relatively more maize than the poorer category of producers (Balderrama *et al.*, 1988:30). Rich farmers grew the least maize, however, and the reasons for this are not clearly apparent though the authors suggest that this is because 'the wealthiest households do not have to risk maize cultivation [as a cash crop]'.

3.4.3 Conclusion to Section 3.4

This section has shown that farmers have developed active strategies in response to, and to cope with, the contrasting constraints and inter-annual variability of the two ecological zones. Although these strategies do ameliorate the ecological contrasts between the zones somewhat, it is also shown that people utilise opportunistic strategies which maintain, or even enhance, underlying variability.

3.5 Conclusion to Chapter Three

Chapter Three has described the baseline ecology of the semi-arid study area, focusing on documenting the contrast in the productivity dynamics of the agro-ecosystems of sandveld and clayveld. Clayveld productivity is shown to be much more variable on a seasonal and inter-annual basis, even under the same rainfall regime as sandveld. This basic contrast is used to investigate contrasting patterns of food production (Chapter Four) and in nutritional status (Chapter Five). Ecological differences, particularly in respect of seasonal swamps and dust levels, are then used to predict contrasting seasonal and inter-annual morbidity patterns (Chapter Six). Food production and disease environment factors conditional on the ecological dynamics examined in this chapter combine to influence mortality and fertility (Chapter Seven); and shape the nature of rural differentiation and change (Chapters Eight and Nine).

CHAPTER FOUR

FOOD PRODUCTION AND CONSUMPTION

Introduction

This chapter forges the link between the ecological dynamics explored in Chapter Three and the human biological variables addressed in Chapters Five to Eight, by examining the household economy and food consumption. Three issues are highlighted. First, inter-annual variation in food production and consumption, especially the fact that it is most marked in the clayveld zone. Second, the seasonality of food system, and that it is less marked in the sandveld than clayveld zone. Third that the population is economically differentiated so that food production and consumption can be contrasted between wealthy and poor, which can be predicted to affect their welfare status (which can then examined Chapter Eight).

4.1 Household Demography, Productive Assets and Economic and Ecological Differentiation

In this section the productive assets of the relatively wealthy and poor population categories in the different ecological zones are compared. This shows significant contrasts between relatively 'wealthy' and 'poor' people, though the patterns are complex and varied between zones and populations.

Table 4.1.1 provides quantitative data on economic differentiation in each of the ecological zones.

Differences in household size and composition

In common with many African rural societies wealthy households tend to have more members than do the poor. One reason for this is these are 'people-hungry' societies where labour is frequently a constraint. People are recruited into households, and larger households get richer. As this is a polygynous bridewealth-based society, the marriage of additional wives by wealthy men is a key strategy for increasing household size. In addition to this, children (and sometimes adults) tend to join and accumulate in the richer homes. For example, boys often join wealthy households to herd their cattle in exchange for school fee payment.

Table 4.1.1. Economic Differentiation by Wealth Rank in the Three Ecological Zones

	Sandveld				Boundary				Clayveld			
	Wealthy		Poor		Wealthy		Poor		Wealthy		Poor	
	HHold	AEU	HHold	AEU	HHold	AEU	HHold	AEU	HHold	AEU	HHold	AEU
N. HHolds sampled	6		1		8		13		19		22	
HHold size 1986-7	15,7	-	5,0	-	11,0	-	8,7	-	10,2	-	8,7	-
AEU/HHold 1985-6	8,4	-	4,4	-	6,7	-	4,4	-	6,0	-	5,0	-
1986-7	9,2	-	4,4	-	7,2	-	5,4	-	6,4	-	5,6	-
1987-8	9,4	-	4,6	-	6,7	-	5,4	-	6,3	-	5,2	-
Age HHold head	5,2	-	6,0	-	5,4	-	5,2	-	5,6	-	5,2	-
Arable land (ha)	7,7	0,8	5,8	1,3	6,8	0,9	4,4	0,8	5,5	0,9	4,6	0,8
Farm equipment	2,7	-	1,0	-	2,3	-	1,4	-	2,3	-	1,8	-
Cart	0,7	-	0	-	0,9	-	0,1	-	0,6	-	0	-
Cattle	12,5	1,4	2,0	0,4	13,0	1,8	2,9	0,5	7,5	1,2	0,5	0,1
Goats	23,3	2,5	17,0	3,9	29,3	3,9	8,6	1,6	25,0	3,9	11,7	2,1
Donkeys	5,0	0,2	nd	nd	2,8	0,4	0,4	0,1	0,8	0,1	0,1	0,0
Chickens	63,0	2,8	nd	nd	16,0	2,2	10,3	1,9	20,6	3,2	11,8	2,1
Sheep	0	0	nd	nd	0,4	0,1	0,2	0,0	3,4	0,5	0,1	0,0
Total cash income	1493	159	313	68	1330	199	587	109	1130	179	497	89
Remittance income	213	23	30	7	718	107	286	53	633	100	258	50
Tin roof	0,3	-	0	-	0,6	-	0,1	-	0,5	-	0,5	-

Notes to Table 4.1.1:
Ian Scoones computed most of the figures in this table (pers. comm. 1989), using data derived from both our studies. Exact data origin is defined below. Wealthy and poor are defined as wealth ranks 1+2 versus 3+4 respectively. (See Methods Chapter, and Scoones, 1988c, for explanation of these wealth ranks which were ascribed by the community and research team.)

Households were often difficult to delineate. In eight of the 69 'households' members of the homes in question were themselves uncertain as to delineation. In three of the 'households' "domestic cycle" processes during the three years of study led to the creation of new households from semi-autonomous groupings within existing households. For ease of analysis these were defined during the middle of the study period; late 1986, and their status considered constant. The criteria that locals use was not common ownership or holding of assets such as fields, stock or granaries (these are always individually owned); nor was it common consumption (senior women within one home will cook separately; whilst most householders are allocated to one kitchen, some senior men, receive food from each kitchen.) 'Household' authority derives from ownership of space; the 'head' is the owner of a portion of land on which anyone living falls under his authority (even where the head/owner is subordinate to another member socially; several fathers were living in households belonging to their sons. The spatial boundaries can move parallel with domestic processes. In the research arrangement I was responsible for making the household delineations, collecting demographic data and listing the members for each and their presence absence status.

Notes to Table 4.1.1 continued

AEU are Adult Equivalent Units, derived from nutritional estimates by Latham for East African rural populations for FAO (presented in Collier *et al*, 1986:71).

<table>
<tr><th>Age</th><th>Male</th><th>Female</th></tr>
<tr><td>0-2</td><td colspan="2">0,40</td></tr>
<tr><td>3-4</td><td colspan="2">0,48</td></tr>
<tr><td>5-6</td><td colspan="2">0,56</td></tr>
<tr><td>7-8</td><td colspan="2">0,64</td></tr>
<tr><td>9-10</td><td colspan="2">0,76</td></tr>
<tr><td>11-12</td><td>0,80</td><td>0,88</td></tr>
<tr><td>13-14</td><td>1,00</td><td>1,00</td></tr>
<tr><td>15-18</td><td>1,20</td><td>1,00</td></tr>
<tr><td>19-59</td><td>1,00</td><td>0,88</td></tr>
<tr><td>60+</td><td>0,88</td><td>0,72</td></tr>
</table>

Ages were calculated on the basis of calender years; clearly ages increased and household composition changed for each year of the agricultural monitoring.

Household size refers to the situation in 1986-7. Members reported absent were discounted to 0.1 and members alternating in their presence-absence multiplied by 0.5.

Age of household head is a mean of the decadenal categories used. Category five is 40-49 year olds, category six 50-59 year olds.

This demographic and household composition data is all derived from my survey data, except for presence absence data used in the calculation of AEU for 1987-8 which were produced in collaboration with Ian Scoones. Date of birth was obtained as accurately as possible for all those under twenty years, and the remaining population grouped into decadenal age-categories.

Field area was measured for 134 field units in early 1987 with the help of mainly Abraham Mawere and B. Mathou Chakavanda. Johnson Madyakuseni helped with the fields of one sample cluster on the Sunday evening before I left. 7 further field units were measured for me by Ian Scoones and B. Chakavanda in mid 1987. We failed to measure 14 of the fields held by the sample. Field area was determined by identifying on the ground current field boundaries and tracing over the centre of an 1985 aerial photograph on a 1:6250 scale. (Generally speaking there was little change in the extent of fields in the two years.) Area was then determined by placing the tracing over graph paper and counting the squares. Net field area exclusive of contour ridges, pans, paths, rocky outcrops, etc. was calculated. No account could be taken of slopes, though these were generally gentle, nor of the minor altitude changes that may have affected scale. Field area was calculated per AEU using the 1986-7 demographic data.

Equipment refers to ploughs, cultivators and harrows. Each was scored as one and the number of distinct articles summed. Multiple ownership of ploughs, etc., was not scored extra. Equipment data was collected by myself and Abraham Mawere in mid 1986. Cart refers simply to whether a cart is owned within that 'household', with "yes" scoring one and "no" scoring zero. Cart data is also derived from my mid 1986 survey with Abraham Mawere.

Stock ownership refers to the number owned by the members of that household, irrespective of whether they are held at that home, or elsewhere. The complexities in the definitions of ownership are explored in Scoones and Wilson (1988). Stock holdings were initially surveyed by Abraham Mawere and I in early 1986 and then monitored to late 1987 by Ian Scoones (with Florence Shumba and then Abraham Mawere). The timeline for goat and cattle holdings was mid-1987, this data being collected by Ian Scoones and Abraham Mawere. Stock per AEU are calculated from the 1986-7 demographic data. Donkey, chicken and sheep data are derived from my 1986 survey. Only one household in sandveld was included at that stage. No chicken data exists for six of the households in clayveld. Additional livestock were all held in small amounts; a total of two pigs, ten ducks, eight rabbits and three guinea pigs in mid 1986.

Total cash income and remittance income are provisional estimates from the monitoring of these households in late 1986 to late 1987 by Ian Scoones with first Florence Shumba and later Abraham Mawere. Income data, which is in Zimbabwe dollars, refers only to cash income, and not to any other measures of production. The 1987-8 AEU data is used to convert this to per capita figures.

Tin roof ownership was counted as one and non-ownership as zero. The data is derived from my household inventory with Abraham Mawere and M. Mukamuri-Ncube in mid 1986.

Differences in household size and composition, continued

In contrast to the accumulation of people by households for economic gain is the fact that there are also economic disadvantages of having many dependents. Indeed rather than getting wealthy from being large, homes with greater incomes also grow as they can 'afford' to support more people. Patriarchs struggle to get as many wives and dependents as possible, as this gives them a greater sense of authority (political and sexual). Indeed, they can accumulate people to the point that they are severely economically stretched, especially given the current challenge of secondary school fees.

Households tend to be largest in the sandveld. This is related to the higher polygyny rate in this zone, which is linked to 'traditionalism'; in contrast to clayveld which is styled as a flexible 'immigrant' society for historical reasons (Appendix Two). More importantly, a large proportion of sandveld homes are members of the chiefly lineage who draw attention to their status and enhence their prestige through polygyny. Furthermore, people frequently reported economies of scale resulting from polygyny in the countering baboon raids on fields, which are extremely significant in this sandveld ecological zone (see Chapter Three).

Data on changing household size (AEU for 1985-6 to 1987-8) suggests an interesting contrast between ecological zones. Sandveld populations increased steadily, whilst boundary and clayveld populations were held constant or declined in 1987-8. This was not due to mortality or depressed fertility (see Chapter Seven), but because the population was sufficiently badly struck by drought in the clayveld and boundary zones to prompt out-migration of individuals (mainly children) into towns and sandveld areas and to reduce the number of long-term visitors.[1]

Mean age of household 'head' (owner) is little different between the wealthy and poor and in the two zones. This perhaps reflects the fact that there are many 'routes' to wealth, rather than the fact that age does not affect wealth. Generally speaking, the agriculturally wealthy are elderly men, but likewise most of the men who are wealthy primarily through remittance are young. Large samples and disaggregation would be required to explore the impact of age in a thorough manner statistically.

Differences in arable land area and agricultural equipment

Although field area is greater in richer households there is no difference in the area per Adult Equivalent Unit (AEU), ie. land area per household member remains constant. Differentiation in land area access is therefore not an important factor behind wealth differentiation in this less densely settled part of Zimbabwe. This reflects two factors. First, the implementation of the Native Land Husbandry Act (1951) which was designed to cut African holdings down to an equal minimum (Duggan, 1980).[2] These allocations are still largely reflected today. Second, households that grow in size sufficient to become constrained by land are able to obtain additional fields to compensate for this. This can be through pressure of rights/needs within the shallow patrilineage which allocates heritable land; through allocation (legal or illegal) of additional 'commons' or other available land by community leaders; and third by simply individually taking over land through **madiro**.[3] An assessment of arable land holding by members of the chiefly lineage, leaders of the chiefly lineage, recent immigrants (post 1964), and 'master farmers' showed that it was only the 'master farmers' who actually have a different amount of land per household member than the population as a whole.[4] There has been a general assumption in the literature that the master farmers are inherently privileged by land ownership, and hence cannot be emulated by the bulk of farmers. However, in this study each of these master farmers had recently taken over larger areas of previously unfarmed land, so that large land holdings actually only reflect draught-power, labour, capital and skill advantages. The majority of other farmers leave areas of their land fallow in most years because they have not the 'means' to use it. It is yields per unit land and not land area owned *per se* that make the largest contribution to production differentials between the wealthy (cattle owners) and the poor.[5]

Households in wealthy categories in all zones own more agricultural equipment (ploughs, cultivators, harrows) and carts than the poor. Whilst ownership of such assets is important in economic differentiation, ultimately these still largely reflect only inequality in stock. Yet stock owners who own carts can make much more use of their stock, including hiring out to others, than stock owners without carts. Carts require considerably more capital than other agricultural and domestic items.

Levels of equipment ownership are approximately similar between ecological zones, except that carts are more frequently held by the sandveld and boundary populations. Carts have extra value in this zone due to the requirement to transport manure to maintain soil fertility (Chapter 3.4.1).

Differences in levels of stock ownership

Cattle holdings at the time of monitoring (1986-7) were much higher in the sandveld and boundary populations than in clayveld. This is presumably related to the higher level of livestock deaths in the herds owned by the clayveld farmers during the recent drought (1982-4).[6]

Cattle ownership is extremely skewed between the rich and poor categories of farmers in all ecological zones. In the sandveld and boundary zones the wealthy households own more than three times as many cattle per person (AEU) as do the poor, in the clayveld the difference is over ten fold. Greater wealth differentials on clayveld may be related to the excessive stock deaths in the clayveld zone in the 1982-4 drought: which preferentially struck poorer households who proved less capable of maintaining their herds (personal observations; and Ian Scoones, pers. comm., 1988). Furthermore, subsequent to the drought poorer households have been less able to restock than the wealthy, so fell further behind.

Farmers perceive cattle access as the critical factor behind differentiation in food production and security (cf. Callear, 1984:166; and Caron *et al.* 1988:80-2), due to the dependence upon livestock for agricultural production (for draught power and manure, see Chapter Three, Section 3.4). However, the relationship between ownership, access and production is complex as the wealthy and poor are involved in intense 'sharing' relationships over these stock (Scoones and Wilson, 1988).

Although donkeys are often characterised as 'beasts of the poor' there was no difference between the degree of skewness of donkey and cattle ownership. Donkeys are a cheaper alternative to cattle for ploughing, but are also important as superior beasts for drawing carts.

Goat ownership shows a less marked disparity between wealthy and poor farmer categories. The wealthy own on average about double the number of goats of the poor (per AEU). Goats are used both for providing meat and also for economic speculation. Due to the low capital requirement even poor people can invest in a few goats and then accumulate them. The ownership of chickens is even less biased than that of goats, with the rich having only somewhat larger holdings than the poor (per AEU).

Differences in cash and remittance incomes

Cash and remittance incomes per AEU (ie. income in addition to 'subsistence' production that does not enter the cash economy) are highest in the boundary population. This is perhaps linked to their lower involvement in agricultural production with both affecting the other.[7]

Remittance income is particularly low in the sandveld population. This is related to the fact that in this particular area the homes have invested heavily in intensive (wetland) agriculture. Men are needed at home (and can achieve reasonable returns), and children are required for guarding against baboons and for agricultural labour, rather than attending school and out-migrating. To some extent this bias against education in baboon-afflicted villages is now declining due to the great emphasis being placed on education since Independence and the growing disparity in urban-rural potential income differentials. However, children in sandveld populations still often find that they are forced to do rotas of protection within their supposed schooling time.

Frequency of non-thatch roofing use

The use of corrugated iron and reinforced asbestos as roofing material is most common in the boundary and clayveld populations. Thatching grass availability is lower in these areas. Although some grass is imported from neighbouring commercial 'ranches',[8] and from better watered areas such as Mt Buhwa, the shortage of grass is such that it provides a real constraint on roofing in those zones. Women have to gather the necessary grass from contour ridges within the fields at the time of harvesting. Grass is available on ridges because stock have been herded away from the fields during the rains. Gathering the grass competes with harvesting labour because the grass has to be cut before stock are allowed to graze in the fields after harvest. The shortage of grass has led to greater use of the crop stalks, especially bulrush millet, as underthatch. The declining availability of thatch reinforces the social status advantage of tin roofs.

Iron and asbestos sheeting are more common in wealthy households. This is presumably because they require considerable capital investment (including for building rectangular brick houses and buying the necessary supporting wooden beams). Though they make the homes less habitable during the hot and cold seasons by exacerbating temperature changes, tin roofs are helpful during times of excessive rainfall, especially if sufficient grass is not available for good thatching. Leaking roofs are a much greater problem for the wealthy, as they have furniture that can easily be damaged.

Conclusion to Section 4.1

This section has shown that there are marked differences in household demography and productive assets between ecological zones and wealth categories. These differences are interpreted in the light of the production systems of the different zones, and their ecological dynamics. Lineage relations can also be seen to have strongly modified these relations. The underlying economic contrasts between sectors of the sample population will now be used to explore differences in food production and consumption (Sections 4.2 and 4.3).

4.2 Cereal production and consumption

Cereal production, sales and consumption data for the period 1985-7 were collected to examine differences in food production and consumption between ecological zones and wealth categories.

4.2.1 Cereal Production

Table 4.2.1.1 Cereal Production and Sales by Wealth and Ecological Zone

	Sandveld		Boundary				Clayveld			
			Wealthy		Poor		Wealthy		Poor	
Households	n=7		n=6		n=13		n=19		n=22	
AEU/HHold 1986-7	7.9		7.2		5.4		6.4		5.6	
	Kg/AEU		Kg/AEU		Kg/AEU		Kg/AEU		Kg/AEU	
	mean	σn-1	mean	σn-1	mean	σn-1	mean	σn-1	mean	σn-1
CEREAL CROP YIELD										
1984-5	1515	1530	592	209	645	350	1219	770	743	339
1985-6	400	236	72	37	74	120	193	198	95	75
1986-7	291	190	62	38	42	27	92	74	98	123
Total Yield 1984-7	2206		726		761		1504		936	
% in wet 1984-5	69		82		85		81		79	
* Tot yield as % of energy requ. (3000/kcal/day):										
75% requirement	313		103		108		214		133	
60% requirement	392		129		135		267		166	
CEREAL SALES										
1984-5 GMB	486	779	181	84	32	42	487	445	125	151
Other	82	146	0	-	11	25	0	-	22	45
1985-6 GMB	60	106	0	-	0	-	24	68	0	-
Other	78	138	0	-	0	-	31	88	0	-
1986-7 GMB	0	-	0	-	0	-	0	-	0	-
Other	25	44	0	-	0	-	0	-	0	-
Total Sales	731		181		43		542		147	
% in wet 1984-5	77		100		100		90		100	
Sales as % yield	33		25		6		36		16	

Notes to Table 4.2.1.1:
'Wealthy' refers to ranks one and two and 'poor' to ranks three and four as in Table 4.1.1
AEU (adult equivalent units) are defined Table 4.1.1.

Data refer to the all cereals maize, bulrush millet, sorghum and finger millet. People also purchase wheat bread (see Table 4.3.3.1). All data in this table are derived from agricultural monitoring with Abraham Mawere, and analysed together with Ian Scoones.

Sales are divided between 'GMB' (Grain Marketing Board), which are well reported, and 'Other' which are largely semi-legal local sales and exchange, with some illegal sale in town and are under-reported.

FAO/WHO energy requirements are currently generally set at 3000Kcal/day for an adult man (what I refer to as an AEU). Energy value of cereals is taken as 3500Kcal/Kg. Cultivated cereals probably contribute between 60 and 75% energy requirements. One careful study of child food intake in Nigeria found cereals to comprise just over 60% of the energy content of the diet (Nnanyelugo, 1982); carbohydrate intakes would be expected to be a greater proportion adult intakes, and was observed as 60-75% in part of Nigeria (Collis *et al*, 1962;143), 70-90% in Mali, Mondot-Bernard quoted in Martin (1985;289), and 75% amongst Bemba (Richards, 1939). De Garine and Koppert (1988;216-7), monitoring two West African savannah populations, found that the proportion of cereal carbohydrate in the diet varied from 54% and 94% with season and population. This study well illustrates that it is impossible to define a single statistic for carbohydrate consumption. Furthermore, as established in Bennet's Law, the starchy staples ratio declines as household income rises (Stanning, 1988; Gaiha and Young, 1989), so the proportion occurring in my data can broadly be expected to vary with wealth.

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* Tot yield as % of energy requirement: refers to the degree of requirements met by the harvests of 1984-87 according to cereal consumption at 60% and 75% of WHO standard requirement of 3000 kcal/day. (Body weights are not known, however.)

Differences in overall production between zones

There are marked differences in overall levels of production in the three zones. Higher production in the sandveld sample than the clayveld partly reflects the fact that the small sample of farmers in this zone are biased towards exceptionally high-producing farmers, as explained in General Methods. Yields in the boundary population are only half that found in the other zones. It had been expected that access to both sand and clayveld, as well as the high level of cattle ownership, would mean higher agricultural production in this zone rather than lower. Low boundary population yields may partly be an artifact of sampling, in that the highest producing cluster of households failed to submit adequate data for this analysis.[9] But there is nevertheless believed to be lower production in this zone, with socio-economic rather than 'ecological' causes. One factor is probably the greater reliance on remittances (Section 4.1, and see below). Socio-historical factors probably also contribute to lower production in the boundary population. This is a population dominated by the senior chiefly lineage factions and particularly well-established houses of outsider lineages. (This is because historically it was the preferentially settled zone: see Appendix Two.) Thus these households tend to operate within a more highly developed patrilineal framework than those in the clayveld population. These links provide greater security on the one hand and obligation to redistribute on the other. This may reduce agricultural effort because of decreased risk of low production leading to destitution, and less opportunity for high producers to reap the benefits.[10] These households have historically been wealthy in stock (and despite the droughts of the 1980s are still the wealthiest: Table 4.1.1), and therefore are less vulnerable to cereal shortfall, and this may be a further factor reducing agricultural effort.

Production appears robust from the point of view of food security in all three zones, even over a three year period with two virtual crop failures. As indicated in Table 4.2.1.1, even if cereals are consumed to a level of 2250kcal/day/AEU all categories of households and zones would on average be self-sufficient (but, of course, individual households will be divided between surplus and deficit status). Yet in practice self-sufficiency is frequently not achieved as a proportion of the harvest is sold (even by households in overall deficit categories), is brewed into beer, lost to weevils, used as seed, etc. (See below, for attempts to examine this critically).

Cereal sales are a similar proportion of yields in the sandveld and clayveld samples; though the absolute amounts are greater in sandveld (probably due to the sample bias towards wealthy farmers). In the boundary population levels of sales are very low, and are a much smaller proportion of the total yield. This is presumably a function of the fact that these households are barely reaching food self-sufficiency, and as argued above this is thought not to be due to 'ecological' factors.

Inter-annual variation in yields and sales

Cereal yields in all three zones have high inter-annual variability, but sandveld shows less variation than clayveld (as predicted in Chapter Three). During the years 1984-5 to 1986-7 the single high-rainfall year (1984-5) dominated overall production to a greater extent in the clayveld than sandveld zone (80% versus 69%). Crop yields in the high rainfall season of 1987-8 (c800mm) illustrate the bad effect that a poor distribution of high rainfall can have on sandveld yields. Harvests were considerably down in sandveld because heavy rains led to leaching in top lands and flooding in the dambos, whilst yields on the clayveld were relatively good. The data from this year, though well illustrating the negative effects of high rainfall on sandveld, are not included in the analysis in this thesis. An unexpected result is that the contribution to total harvest in the single wet year in the boundary population was somewhat more even than in the clayveld. This might reflect a less risk-aversive agriculture in that zone, given the importance of remittances and other security-promoting factors discussed above, but the agronomic data to investigate this has not been evaluated.

Sales were concentrated in the single year of high rainfall (and high yields), but in the sandveld unofficial sales continued throughout all three years. Indeed such sales were probably higher than reported (especially in 1987), as the prices became elevated above the legal prices due to shortage. Official sales to the Grain Marketing Board (GMB) were concentrated in the single year.[11]

Differences in cereal production between wealth categories

In clayveld there is a notable difference in overall cereal production between wealthy and poorer categories. In contrast the difference in sandveld is slight whilst cereal production in poor and wealthy household categories was identical in the boundary population. This may reflect the fact that the boundary and sandveld populations are particularly organized around patrilineal stock 'sharing' groups with an egalitarian ideology. Diagrams of the stock sharing arrangements of several such groups are provided in Figure 4.2.2. Quantitative data on stock use and consequent yields in the fields of this population have not been analysed to investigate this hypothesis. Social organisation along these lines is probably linked to factional political struggle between segments of the chiefly lineage. Such sharing is also found in the clayveld sample, but, at a population level, it appears less egalitarian (in an economic sense) and not as intense. Stock ownership in the boundary sample is also less skewed than in the clayveld population. This fundamental difference in the nature of economic differentiation shows up very clearly in nutritional status (Chapter Eight).

It is striking that where there were cereal yield advantages gained by wealthy households over the poor (that is in clay and sandveld), this was in the high rainfall rather than in the severe drought year. This contrasts with the thrust of the research literature on drought vulnerability which has concentrated on production and exchange during drought, ignoring whether the more significant effects might be seen in the intervening high rainfall years. Agronomic data to investigate why this pattern of differential production occurred have not yet been analyzed. However, at the time it was notable that it was poor farmers who struggled especially hard to produce in the drought year 1986-7 as it was they who were truly threatened by food shortage. Severe drought years that do not strike at times when the poorer categories are short of food may not therefore produce similar effects, this issue would require further research. More risk aversive farming practices by poorer farmers (See Chapter Three, Section 3.4, for qualifications), may mean that they tend to be out-yielded in the wet years and do relatively well in poor years. A key factor enabling rich farmers to achieve better yields in wet years was their better access to stock to plough large areas, and so take advantage of the high rainfall.

Higher proportions of harvests sold by the wealthier households do not only reflect higher production, since such elevation occurred even in the boundary population where there was no wealth difference in cereal production. The reason may be that the richer can afford to 'risk' sales in wet years as they know that they have independent income and/or stored assets that can be mobilized to meet food needs if drought years follow in succession in future seasons (as they indeed did in the period studied).

4.2.2 Cereal Consumption

Beer Production

Part of cereal production is converted into beer for consumption and sale. This section reports estimates of this volume.

Table 4,2,2,1 Differences in Beer Production by Wealth and Ecological Zone

	Sandveld		Boundary				Clayveld			
			Wealthy		Poor		Wealthy		Poor	
N, Households	n=2		n=3		n=12		n=14		n=15	
	mean	σn-1	mean	σn-1	mean	σn-1	mean	σn-1	mean	σn-1
Kg/AEU 1984-7	22	26	104	53	138	119	49	84	71	71
% Harvest 84-7	1		14		18		3		8	

Notes to Table 4,2,2,1:
Wealth categories and AEU: see Table 4,1,1
Production is not equivalent to consumption since beer is mainly consumed by groups of people: either in rituals (bira and mitoro), work parties (humwe) or in commercial sales (ndari and bharoni).

Poor households produce more beer per AEU than wealthy households in both boundary and clayveld populations; in the boundary populations it is almost significant (t= 1,46; 13df); and in clayveld highly significant (t=2,79, 27df).

The use of cereal to produce beer is particularly important in the boundary population. The high consumption of beer in this sub-sample reflects the fact that many of those households are members of **bharoni**, which are beer producing organizations which also partly function as savings clubs through a system of reciprocal money exchanges. Additionally some households put considerable effort into producing beer for sale (**ndari**). The use of beer for attracting work party labour (**humwe**) is also especially common in households in this sub-sample. In the boundary population there are relatively few (abstaining) fundamentalist Christians, which may reflect the fact that for historical reasons the boundary population holds political power in the area. Since they achieve this by means of control of land and rain through ancestral spirits and their supplication with beer, they eschew fundamentalist Christianity. Furthermore, the close lineage ties characteristic of this zone promote the beer clubs (**bharoni**) and the use of **humwe** (beer-work) work parties.

Poorer households produce more beer than wealthy households. This may partly reflect beer production for sale being more common in poorer households. However, the research team was frequently informed by local people (both drinkers and abstainers) that households engaging in beer production and consumption tended to be poorer as a result. (Beer consumption per adult is also higher in poorer households: Section 4.3.)

Consumption of cereals as food*

Two methods were used to estimate cereal consumption. The first was to ask households to state their monthly flour consumption. The second was to estimate the amount of flour used during the food consumption monitoring on the basis of pot sizes. The results of these methods are critically evaluated at the end of this section through the use of a grain flow model.

Womens' monthly consumption estimates

Women know how much grain they take to be ground at commercial hammer-mills quite well, as they have to pay there per bucket, making them acutely aware of how much they have to budget. This enables a monthly cereal consumption estimate. The question was asked on two occasions: in mid-late 1986 and in mid 1988,[12] allowing for general cross-checking and comparison. However, even if the amount of grain milled is known by women, it does not mean that it will be objectively reported. The principal factor leading to distrust was that food aid was to be distributed to the population due to low rainfall; but this, in itself, was hardly of sufficient magnitude to elicit a highly biased response. Other ambiguities remain, however, since milled grain is not the only way that cereals are consumed (see Section 4.3.1).

In order to calculate consumption per Adult Equivalent Unit (AEU), household size in AEU was regressed against stated consumption, as part of the grain-flow model. The result is presented in Table 4.2.2.3

* An important caveat on the whole of this discussion of cereal consumption estimates in this section, is that comparisons made between ecological zones and by wealth, and in reference to international standards, ASSUME EQUAL MEAN BODY WEIGHTS, and must also consider ACTIVITY LEVELS. No data exist to establish this, except some minimal data on 'wealthy' versus 'poor' women in clayveld (Table 8.1.3, p326), which suggest that 'wealthy' women are, in fact, heavier.

Table 4.2.2.3 Daily Self-Reported Flour Consumption Figures: Correlation of AEU versus Kg consumed by wealth (Kcal Per AEU)

	Wealthy			Poor			Total		
Kcal/AEU/Day	**n**	**mean**	**r^2**	**n**	**mean**	**r^2**	**n**	**mean**	**r^2**
Mid 1986	19	1497	0.75	25	1585	0.47	44	1526	0.62
Mid 1988	23	1993	0.75	27	1643	0.11	50	1857	0.63

Notes to Table 4.2.2.3:
'Wealthy' and 'poor' categories and AEU are defined as in Table 4.1.1.

N refers to the number of households sampled

The 1986 estimate is a late dry season figure. That for 1988 is a late harvest pre-sales figure after the first harvest in three years

Cereal energy content is taken as 3500kcal/kg.

In 1988 (after a long period of food shortage) there was a difference in cereal consumption by ecological zone, whereas there was none in 1986 following a good harvest (Table 4.2.2.4). This was marked in the 'poor' population category (Table 4.2.2.3), with lower consumption by the clayveld sample.

Table 4.2.2.4 Daily Self-Reported Flour Consumption by 'Poor' in 1988: Correlation of AEU versus Kg consumed by Ecological Zone (Kcal Per AEU)

	Sandveld + Boundary			Clayveld		
	n	mean	r^2	n	mean	r^2
Kcal/day/AEU	12	1857	-0.42	15	1585	0.10

Notes to Table 4.2.2.4:
As in Table 4.2.2.3

The self-reported flour consumption figures are lower than what would be expected on the basis of FAO/WHO recommended intakes (total 3000Kcal per AEU [adult man]). If cereals do indeed contribute 60-75% of the energy intake in the diet, households should have consumed 1800-2625Kcal/AEU/Day from this source.[13] However, considering cereal intake as only flour does ignore the consumption of cereals in the many other ways they are eaten (especially shortly after harvest), see Section 4.3 for details on approximate rates of consumption in this manner.

In both 1986 and 1988 a much closer relationship exists between the reported flour consumption and number of AEUs in the wealthy household category than amongst the poorer, as is reflected by r^2. Amongst wealthier households there may have been greater honesty and/or less variability in consumption levels.

During 1986 there was no difference between consumption estimates for the wealthy and the poor, nor between zones. It should be stressed that this only refers to cereal intake as flour. Section 4.3 shows that there most certainly were other dietary differences between the wealth categories at this time. During 1988 wealthy households were reporting consuming more flour than were the poor. This estimate was made at a time when a new harvest was replenishing the granaries but prior to end of the cash crisis existing in all but the wealthiest households as a consequence of two previous crop failures.[14] It is striking that the difference in consumption reported was not that the poor were eating less than in 1986; rather it was that the wealthy were eating more cereal than previously. No quantitative data exist but this extra consumption of cereals by the wealthy is almost certainly a response to a decline in consumption of bread and other foods, due to lack of money to buy it. The poor were not in a position to make such compensatory responses.

Table 4.2.2.4 demonstrates a difference in the level of cereal consumption by the poor in the two ecological zones. In the sandveld and boundary population, which is expected to be less vulnerable to drought for ecological reasons (Chapter Three), the poor households reported consuming considerably more in the period of dearth than do the poor in the more vulnerable clayveld population, suggesting that it is in the clayveld zone that food intake in poor households is most vulnerable to drought. However, there is very high variability in this result.

Direct Flour Consumption Estimates

These direct estimates were made from enumeration of meals and estimating flour use per meal. Problems with the method will be reviewed below.

Table 4.2.2.5 Flour Consumption From Meal Records (Kcal/Day/AEU) 1986-7

	Boundary								Clayveld							
	Wealthy				Poor				Wealthy				Poor			
	n HH	n mls	mean	σn-1	n HH	n mls	mean	σn-1	n HH	n mls	mean	σn-1	n HH	n mls	mean	σn-1
Dry	3	45	3313	561	4	57	2616	644	6	61	2392	1398	4	37	1860	522
Harvest	1	14	3675	-	3	38	2812	1518	4	29	2087	768	5	53	2174	1356

Notes to Table 4.2.2.5:
'Wealthy' and 'poor' household categories and AEU are defined in Table 4.1.1.

N/HH refers to the number of kitchen units surveyed, and n mls, the number of sadza meals cooked by those kitchens during the time period assessed. In the boundary samples the three kitchens which had been assessed independently had to be combined for this analysis. Generally speaking the same households were assessed at each time point, though there were some minor changes and omissions due to inadequate data.

Dry season time line refers to the late dry season, August/September 1986
Harvest refers to the early harvest season, March 1987.

Cereal energy value of flour is taken as 3500kcal/kg. Quantities of flour were calculated from an estimation of the quantities of flour required to cook sadza in different sizes of pots. During the enumeration of the meals the pot size was recorded; pot size is standard and marked on iron pots by the industrial manufacturers. Clay pots (which are occasionally used) can be sized in relation to the metal pots. These pot sizes are well known by women who use the size numbers in ordinary discourse. Nearly all meals were cooked in pots of sizes three and four, though there were also quite a number of size twos used. Frequently households alternated between pot sizes for mid-day and evening meals, and the pots were referred to ganerally as 'big' and 'small'. Where pot size was unstated, allocations were made in proportion to stated pot sizes used in that kitchen. If there was such an incomplete record that this could not readily be done the data were discarded.

The amount of flour and water used to make sadza and water in each pot size was determined using a sub-sample of the households. Variability was low, and the estimates therefore considered satisfactory. Pot size two uses 1.3kg/flour, size three 2.0kg/flour, and size four 3.1kg/flour. The ratio of flour to water varied from 1:3.6 to 1:4.1 in sizes 3 and 6 respectively. Duncan (1933:104) reports a general ratio of 1:4 for flour:water when preparing sadza.

The direct estimates in Table 4.2.2.5 are higher than those derived from milling estimates (4.2.2.2 and 4.2.2.3). Though the milling estimate is probably more accurate than direct measurement in this manner it may indeed be on the low side, as is discussed below. At any rate measurement using a different method well illustrates the fallibility of single research techniques. The combined result suggests intakes of between 2000 and 2500 Kcal/AEU.[15] Direct consumption data also provide a valuable further indication of differences by wealth category and also a seasonal effect.

Boundary population households reported greater volumes of **sadza** cooked than did households on clayveld. One factor involved may be that boundary households tended to leave more **sadza** for the subsequent production of sweet beer (**maheu**), see Section 4.3.4. However, the overall reasons for this result are unknown, and may also include reporting artifacts.

Consumption of flour in most categories is higher in the harvest season than the dry season, even though in the harvest season very large quantities of other foods are also eaten (see Section 4.3). This suggests that food intake may be higher at this time of year. Temperatures are lower and there is more agricultural activity than in the dry season so this may partly reflect greater energy requirements. Studies of savannah populations generally indicate increased food intake at times of higher energy expenditure, and also post-harvest (see Chapter Five, Section 5.2). The increase in food intake at this time may also facilitate seasonal weight gain, especially in sandveld.

Wealthier households generally reported consuming more flour per AEU than did the poorer ones, even in the dry season of 1986 when the same households reported no difference in amount of flour milled between wealth categories. Note, however, that standard deviations are high and sample sizes very small.

4.2.3 Consumption, Storage, Purchase and Cereal Balance

Introduction

Material presented in Sections 4.2.1 and 4.2.2 indicate the unevenness of production of cereals through time, drawing attention to the importance of storage over periods of years. However, it is well known that cereal storage under village conditions in tropical countries incurs considerable losses, and these need to be evaluated if the cropping and consumption strategies of savannah peoples are to be understood (as is shown so neatly by the modelling analysis of Dugdale and Payne, 1987). The material presented in this section also suggests that consumption varies through time, and that existing data on the quantities consumed are unreliable. In the following section the results from a 'grain flow model' that tests likely outcomes of different levels of consumption and weevil damage on domestic food supply are reported.[16] These results are compared with existing data on quantities of grain believed held in storage half way through the time period examined by the model, and again at the end of the period.[17] Further comparison can also be made with data on amounts of purchased flour.[18] The modelling also acts as an indirect test for the data on production.

The model assumes that households start off with zero storage at the end of the devastating 1981-4 drought (which is possibly not the case in sandveld, but otherwise makes good sense). Then for each of the agricultural years 1984-5, 1985-6 and 1986-7 the harvested grain is added in, and sales disposed of. Grain is then consumed during the subsequent year (to the next harvest) at constant annual rates derived from the estimates in Section 4.2.2 for beer and flour. Weevils are calculated to consume stored grain at a specified rate per annum (10% or 15%). In the case of grain consumed during the intervening time period, consumption rate is assumed to be constant and the weevil-loss calculated on a half life of consumption. Stored grain is carried over from one year to the next, and is destroyed by weevils at a given constant rate over this time period. When a household enters grain deficit, consumption is assumed to continue at the same rate, from purchased, begged or borrowed sources, but there are no storage losses calculated on purchased grain/flour, as these are assumed short term. All calculations are made on a household basis, and then per AEU in that household, in order that correct account can be made of storage and deficit losses, etc. As would be expected, the model makes a number of dubious assumptions, some of which overlook significant food security strategies. One of these strategies is prior consumption of maize that is otherwise rapidly lost to weevils before the use of the better storing millets.[19]

Figure 4.2.3.1 presents the results for a running of the model for wealthy and poor households on clayveld, using direct cereal consumption estimates and a weevil grain consumption rate of 10% per annum. (The results from running the model with different assumptions and for different ecological zones are presented in Table 4.2.3.6 below.) This single run of the model illustrates the basic principles involved and makes a number of pertinent points.

First, the model illustrates how grain storage from year to year provides the backbone of food security; cereal deficits (assumed to be made up from purchases, loans, etc.), are not as large as cereal stores at population level, and, at a population aggregate level, purchases tend to be matched by carried over stored grain. (The timing of cereal purchases is used to demonstrate this further below.) Since weevil losses are a function of quantity of grain in store, and the proportion of grain consumed from the store (rather than purchased), it is not surprising that weevil losses are of declining significance through time as food security becomes increasing precarious. But in those drought years weevil losses on previously stored grain can be as great as 50% of the yields in the drought years, illustrating how weevils and grain carry over between years cannot be ignored in food security analysis. It is the weevil losses following high rainfall years that can be significant for food supply in the years of drought that follow. Weevil losses are smaller in poorer households, due to lower levels of grain storage.

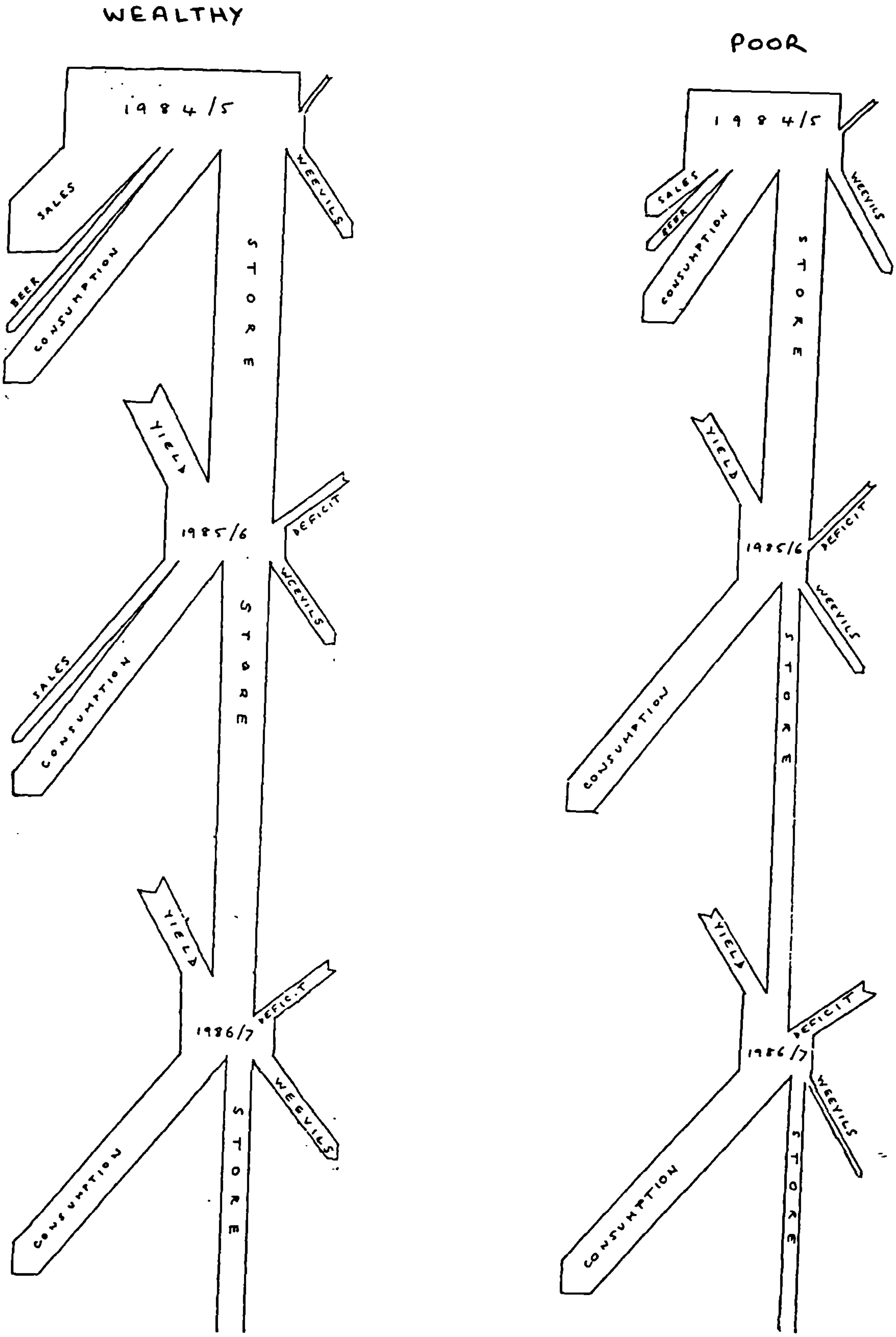
The important point that the big difference in cereal production and use between wealthy and poor households occurs in wet years rather than droughts is presented in a visually clear manner by Figure 4.2.3.1, (see earlier discussion in Section 4.1). This draws attention to the error of most research into drought vulnerability in semi-arid Africa, which focuses on differences in cereal production and use in the drought years themselves. It is in the wet years that the wealthy households achieve production advantages, and capitalise on these through sales (and asset accumulation) and through setting aside adequate storage for forthcoming periods of dearth.

Direct Estimates of Levels of Stored Grain and Purchases

In this section I report direct estimates of grain storage and purchases; data which can be used to test directly whether there are wealth and ecological zone differences in food security, and also to compare with the outcomes of the grain flow model reported below.

Individual farmers were questioned about the amount of grain that they had stored in their granaries,[20] during November 1986 and January/February 1988. Obtaining an accurate estimate of grain holding was extremely difficult, because such figures are usually secret, and people had a number of good reasons for us withholding accurate information from us as outsiders.[21]

FIG 4.2.3.1 GRAIN FLOW MODEL FOR CLAYVELD : BASED ON DIRECT CONSUMPTION ESTIMATE AND 10% WEEVIL LOSS.



Although levels of grain in store in November 1986 were quite variable, grain holdings were still quite high some nineteen months after the bumper harvest of 1984-5 (Table 4.2.3.2). In the clayveld sample the production advantages achieved by the wealthy (Section 4.2.1) were reflected in their reporting holding much larger quantities of grain than the poor. In the boundary population, in contrast, where the wealthy produce similar amounts of grain per AEU (due to intense patronage relationships) but sell a rather more, the poor were apparently holding more grain than the wealthy households per AEU by November 1986. The quantities of grain in store at this time interval on clayveld appear to have been greatly under-reported by comparison with the grain-flow model (Table 4.2.3.6), reflecting the desire to secure food aid at that time.

Table 4.2.3.2 Reported Levels of Grain Storage: November 1986

	Boundary		Clayveld	
	Wealthy	Poor	Wealthy	Poor
Kg Cereal/AEU	66	113	116	57
N. reporting	1	11	17	15
Standard Deviation	-	176	142	49
N. no data	4	3	3	6

Notes to Table 4.2.3.2:
Wealthy refers to wealth categories 1 and 2; Poor to 3 and 4. See Chapter Two.
There was no sufficiently accurate data from the sandveld population, which had very large amounts of grain in store at that time.
For explanation of Adult Equivalent Units see Section 4.1.

Table 4.2.3.3 Proportion of Households Reporting Holding Cereal Stocks in January/February 1988

	Sandveld	Boundary		Clayveld	
		Wealthy	Poor	Wealthy	Poor
Percentage Still Holding Cereal	29%	75%	9%	20%	19%
Sample Size	7	4	11	20	21

Notes to Table 4.2.3.3:
People would simply not countenance systematic questions as to how much grain they had in store; even asking whether they had any at all was considered outrageous given the atmosphere of 'famine'.

Wealthy refers to Categories One and Two; Poor to Three and Four; see Chapter Two.

Cereal stores at the end of the years of dearth can now be examined. Table 4.2.3.3 presents data on the proportion of households stating that they still had grain in store in early 1988. Most of these households said that they had very little, though some admitted having over half a ton per household. The reported results make little sense. Despite the fact that wealthy boundary households ought to have long since run out of grain 75% said that they were still holding grain. This may have been because they started (and maintained) the purchasing of grain long before they ran out, or might possibly be partly an artifact of the social pride of leading chiefly families, loath to admit that they had nothing left. Most sandveld households, however, emphasised that they had nothing left, which might have been a function of sales. Alternatively, they may have wanted to counter the view of the research team that sandveld food supply was fairly secure during drought since this threatened the relief supplies from Government. In clayveld, there appeared to be little difference between the wealthy and poor households. This could reflect the fact that the poor had been forced to purchase more grain in the interim period, but this would not be supported by the data on purchases in Table 4.2.3.4.

Estimates of cereal purchase during the last year of dearth (May 1987-April 1988), including the amounts earned through Food for Work, and are presented in Table 4.2.3.4.

Table 4.2.3.4 Volume of Reported Purchased Cereals in Relation to Food Needs, May 1987 to April 1988

	Sandveld	Boundary		Clayveld	
		Wealthy	Poor	Wealthy	Poor
Kg Purchased/AEU	39	52	109	97	77
N zero purchase	1	0	0	3	1
Kcal prov Day/AEU	374	498	1045	930	738
% 5/87-4/88 Requirements purchased					
At 2250Kcal/day/AEU	17%	22%	46%	41%	33%
At 1750Kcal/day/AEU	21%	38%	60%	53%	42%

Notes to Table 4.2.3.4:
Data on cereal purchase (and Food for Work allocations) was collected by Ian Scoones with Abraham Mawere. These estimates were made retrospectively in October and April. The April questions asked 'since Christmas', and therefore purchases in November and early December were missed. Therefore 10% was added to the annual total.

Calorific content of cereals is taken as 3500Kcal/Kg
For discussion of whether cereal intake provides closer to 1750 or 2250 Kcal/day/AEU see 4.2.2

These food purchase and Food for Work data (Table 4.2.3.4) suggest that around one third to one half of the cereal requirements for the clayveld and boundary populations in the last year of the drought were derived from outside of the area. In contrast, the figures suggest that sandveld households were virtually self-sufficient. Indeed, in aggregate, they probably had more grain in store after the drought than they actually bought during it, even though they would not readily admit to such a fact. This result supports the basic hypothesis that during drought sandveld households will be more self-sufficient than those of clayveld. They achieve this through production during the low rainfall years that is almost sufficient for household needs, as well as high levels of crop storage.

The levels of cereal purchase in the wealthy and poor of the boundary and clayveld populations do not readily make sense in the light of other data. Whereas the wealthy boundary population households should make greater purchases to cope with their deficits than the poor in the boundary sample, they actually report making smaller purchases. The reasons are not known, and it seems strange that the wealthy in this population so under-report purchases. In the clayveld population, in contrast, it was expected that the poor would have to report greater purchases, but in fact the opposite was found. In part this probably reflects the fact that the poor households on clayveld had lower cereal intake during the peak drought period than did the wealthy (Table 4.2.2.4), but this difference should have had a smaller impact than the lower cereal storage derived from the 1984-5 harvest that was still being eaten in 1987-8.

Household cereal purchasing behaviour is complex since people rarely wait until they run out of grain before initiating purchases. Nevertheless, the timing of the onset of cereal purchase is presented in Table 4.2.3.5.

The objective of investigating the date of first purchase was initially so as to demonstrate that households dwelling on clayveld (where production is more drought-vulnerable) would have to purchase earlier than those on sandveld (and boundary), and that the 'poor' have to purchase grain/flour earlier than the wealthy during drought. However, neither of these results was observed. There were negligible differences between wealthy and poor and between the ecological zones. Indeed, when the dates of onset of grain purchasing are analysed a striking result emerges (Table 4.2.3.5). Almost half of the households for whom monthly data are available initiated purchase in the same month: August 1987.

Table 4.2.3.5 Reported Dates of Initiating Flour/Cereal Purchase

Date First Purchased	Sandveld and Boundary n	Clayveld n	Total n
< 6/87	2	1	3
6/87	1	4	5
7/87	0	1	1
8/87	5	8	13
9/87	0	2	2
10/87	1	0	1
11/87	1	3	4
12/87	1	0	1
Unknown "1987"	7	9	16
Total	18	28	46

Notes to Table 4.2.3.5:
The date of first purchasing cereal or flour since the 1985 harvest was collected in a survey undertaken by Abraham Mawere between April and June 1988. This survey was designed by myself, after a request from an NGO.

"Unknown, 1987" means that households reported that the first purchase had been in 1987, but they were unable to recall the month

Data are pooled by wealth, since there were no differences recorded on that basis.

The reasons for this simultaneous purchase (demonstrated in Table 4.2.3.5) are incompletely known; I was not living in Mazvihwa at that time. However, it is obviously not because people individually utilized their granaries until they simultaneously ran out of grain. (In fact some of the people who started purchasing grain at this time admitted to having grain still in store eight months later). It was also not because flour/grain only became available in this month. In fact from early 1987 businessmen had been importing quite large quantities of flour and failing to sell it quickly enough to make it worthwhile given the low return on capital in cereal sales due to Government controlled prices, and the danger for local business-men that relatives and friends will take the bulk of the grain on credit if they do not quickly sell it commercially. However, it is possible that cheaper whole grain maize started to be available at this time, this was sold over the river in Chivi (that was brought by a trader from the productive and wetter lands of migrant farmers in Gokwe). Similarly the peak in purchases was not driven by income, since there was no increase at that time, except a more general coming through of 'Food for Work' money during that dry season.

I am left concluding that social-relationship factors were responsible for the triggering of food purchasing at one particular time. Generally people were anxious to present themselves as in the same food situation as others. Making early purchases either suggested that one was 'rich' - having ample money for purchases - (and this would attract relatives/friends begging for assistance), or it meant that one was a poor farmer or husbandman of a home, having run out of grain. Likewise late purchase indicated that one still had ample food in store - and therefore might agree to part with some to a relative/friend, or that one could not raise the income to do so and hence was essentially destitute. It is worth considering at this point that nearly every household (and indeed individual) is both heavily indebted to other households, and has itself lent out large sums also. Therefore avoidance of appearing to have food or money in a drought is not simply a mechanism to avoid assisting the poor and one's clients, but of maintaining the integrity of the household economic unit.[22]

Domestic Food Security: examining the outcome of models of grain flow

In this section I combine the estimates of grain production, sales, beer use, consumption, purchase and storage to test whether the estimates combine to make accurate predictive statements concerning outcomes. The models (Table 4.2.3.6) combine the known figures with tests of two rates of consumption (those derived from quantities of grain taken to grinding mills, and those from direct measures of volume of food cooked), and two rates of weevil damage (10% and 15% per annum). The outcomes from modelling can then be examined as to how they predict food supply vulnerability to drought in the different ecological zones and socio-economic categories. Table 4.2.3.7 compares the amounts of grain that would have to be purchased to balance reported production and consumption (given the other variables in each model), with the actual amount of grain reported purchased by the households involved.

Table 4.2.3.6 Outcome of Different Runs of the Grain Flow Model (Per AEU)

	10% Weevils Grinding Mill Consump					**10% Weevils Direct Consumption**				
Ecol Zone:	**Sand**	**Bound**		**Clay**		**Sand**	**Bound**		**Clay**	
Wealth:	**1-4**	**1+2**	**3+4**	**1+2**	**3+4**	**1-4**	**1+2**	**3+4**	**1+2**	**3+4**
1984-5										
Store	689	137	270	465	325	504	20	184	399	279
Deficit	0	15	9	0	5	0	99	45	6	9
Balance	689	122	261	465	320	504	-77	139	393	270
1985-6										
Store	616	50	154	373	205	311	0	64	265	138
Deficit	0	19	44	6	12	32	278	144	26	33
Balance	616	31	110	267	193	279	-278	-80	239	105
1986-7										
Store	616	9	77	285	176	274	0	22	185	117
Deficit	0	106	68	28	39	87	306	209	68	92
Balance	616	-97	9	257	137	187	-306	-187	117	25
1984-7										
Culm Deficit	0	140	121	34	56	119	683	398	100	134

	15% Weevils Grinding Mill Consump					**15% Weevils Direct Consumption**				
Ecol Zone:	**Sand**	**Bound**		**Clay**		**Sand**	**Bound**		**Clay**	
Wealth:	**1-4**	**1+2**	**3+4**	**1+2**	**3+4**	**1-4**	**1+2**	**3+4**	**1+2**	**3+4**
1984-5										
Store	647	125	250	435	303	468	17	168	371	258
Deficit	0	16	10	0	5	0	107	47	7	10
Balance	647	109	240	435	298	468	-90	121	364	248
1985-6										
Store	548	41	130	326	175	266	0	55	225	114
Deficit	0	27	46	7	13	38	283	153	28	36
Balance	548	14	84	319	162	228	-283	-98	197	78
1986-7										
Store	517	3	58	226	139	223	0	13	144	94
Deficit	0	111	76	34	45	96	307	210	78	101
Balance	517	-108	-18	192	94	127	-307	-197	66	-7
1984-7										
Culm Deficit	0	154	132	41	63	134	697	410	113	147

Notes to Table 4.2.3.6: The figures presented in the table are derived from running the model discussed in the introduction to section 4.2.3. The models vary in respect of two parameters:

(1) 'weevil loss', either 10 or 15% (usual upper and lower estimates of cereal loss rates in the tropics); and,
(2) 'consumption', either the grinding mill estimates (Tables 4.2.2.3 and 4.2.2.4) or the direct meal estimates (Table 4.2.2.5); in some versions of the model this requires that different consumption rates per AEU are used in different agricultural years.

For details of the wealth categories (1-4) and Adult Equivalent Units (AEU) see Table 4.1.1.

Table 4.2.3.7 Grain Purchase: reported data versus model predictions (Calculated Per AEU)

	Sandveld	Boundary		Clayveld	
	1-4	1+2	3+4	1+2	3+4
Actual Reported Cereal Purchase	39	52	109	97	77
Model 1	0	140	121	34	56
Model 2	119	683	398	100	134
Model 3	0	154	132	41	63
Model 4	134	697	410	113	147

Notes to Table 4.2.3.7:
AEU and wealth categories, as defined in Table 4.1.1

Actual reported data derived from Table 4.2.3.4.

Model data derived from Table 4.2.3.6; models as follows:
Model 1: 10% weevil loss, milling estimate of consumption
Model 2: 10% weevil loss, direct consumption estimate
Model 3: 15% weevil loss, milling estimate of consumption
Model 4: 15% weevil loss, direct consumption estimate

Discussion of the Implications of the Grain Flow Model, Storage and Purchase Data

The model of grain consumption and storage indicates quite clearly that, taken overall, existing data are clearly implausible, indeed that for each population sector they appear to be biased in different directions. Deduction from the model, and from other information concerning the people involved, enables some conclusions about the most likely sources of error. It is worth summing up the probable main inaccuracies, before concluding on the relevance of the model for the argument in the thesis.

First some general points. The model allows scope for manipulation of two elements: first the consumption rates, and second the weevil loss rates, as methods to obtain approximately accurate figures for cumulative deficit and grain in storage. Clearly the two variables interact, as consumption rates determine quantity in storage (and hence amount of maize exposed to weevil damage). It can be noted that the capacity of weevil damage rate to influence outcome declines as stored grain volume falls, since, obviously, weevils can only damage surplus grain holdings. It is therefore impossible to achieve the empirical results reported by the households studied, in which grain deficits (purchases) are relatively low (Tables 4.2.3.4 and 4.2.3.7), whilst final grain volumes in storage are negligible (Table 4.2.3.3). The reasons for this probably encompass both systematic inaccuracies in reporting (see below), and, secondly, the existence of other mechanisms that redistribute grain between households. Presumably exchange of grain between households, including commercially, as loans, and as gifts, is the key factor occurring that balances these two elements. Households would generally under-report such exchanges, although they were obviously occurring.[23] It is also possible that the patterns of consumption were rather different from what was reported. The existing figures ignore the importance of other methods of cereal consumption in addition to as flour (see Section 4.3). The figures also ignore losses of grain mass during preparation (which are particularly marked for bulrush millet), and the use of grain and even cooked **sadza** for feeding chickens, doves, dogs and other domestic animals. Part of the problem in balancing grain supply with consumption is the fact that boundary population 'direct consumption' figures are much higher than those of clayveld (Table 4.2.2.5), a result which seems rather unlikely, and may be a recording artifact of some kind.

Second, several significant innacuracies can be found within the estimates. Sandveld households, for example, appear to have over-recorded yields and/or under-reported sales, probably in the 1984-5 period. This high rainfall year may not have been such a good one as reported on sandveld, and because of the late start to this sample the period of recall (eighteen months) was too long. Clayveld households were clearly greatly under-reporting stored grain in November 1986. Although this was known at the time - since the figures were much less than the figures produced in June - and this was clearly due to the initiation of food aid, I had not then appreciated how under-estimated the figures were. It also appears that yields in clayveld - especially by the wealthy in 1984-5 - were exaggerated by some households, or that major further exchanges of grain occurred. Boundary sample households pose the biggest problem of analysis. According to the empirical data on purchases the wealthy boundary households bought less grain than did the poor, though the model clearly shows that this is hardly credible given the other data reported. It may be that wealthy boundary households harvested more grain than reported, but this is unlikely, as early storage data are reasonable, and is difficult to identify any motivation for doing this. Yet the claim by 75% of the wealthy boundary households to be holding grain at the end of the study period is not credible given their reported lack of purchase; one of the two figures, most likely purchase data, is highly unreliable.

Conclusions to Section 4.2

The result of this examination of the data suggest that there are some fundamental flaws in the grain production and consumption data, the exact nature of which can only be tentatively identified. Furthermore, although a 10-15% weevil loss rate, and consumption figure of between 1500/3000 kcal/cereal/day seem quite reasonable, it is impossible to pinpoint accurate overall figures. This realisation has a sobering effect on the drawing of conclusions on inter-annual variability in food security by wealth and ecological zone. However, it nevertheless remains clear that drought cereal supply is more vulnerable in clayveld than sandveld, and that boundary population "food security" is low, but that they can readily cope with this through purchase. Overall food supply is apparently quite robust, relying on effective storage between years, and reported cereal purchase and consumption suggest that deficit households manage to make good their shortfalls. In comparison of the wealthy and poor household categories the conclusion that there are differences between the boundary and clayveld populations was quite clear, a difference that is shown to have fundamental importance in Chapter Eight. Wealthy households in the boundary population experienced low cereal production, but nevertheless seemed able to cope with this through purchases, though these were not reported in full. Poor boundary population households reported making large purchases successfully, maintaining high food intake. In contrast, the poor in clayveld attempted to eke out smaller supplies of cereal than the relatively wealthy in this zone, and reported making smaller purchases to manage a larger deficit. It was not surprising, therefore, that cereal consumption declined in this population during the peak of the drought. The marked effect that this has on nutritional status of children in the populations will be examined in the next chapter.

4.3 Seasonal, Ecological Zone and Wealth Differences in Diet

This section is based upon a diet survey in a sub-sample of homes in the boundary and clayveld populations. A literate member of the household was asked to record the composition of meals over a week with the support of the research team (myself, Abraham Mawere and M. Mukamuri-Ncube). These were usually young, keen, school girls (or recent school leavers). Young women have been shown to be the most accurate in dietary surveys (Campbell and Dodds, 1967). Continuous recording was thought to be more reliable than dietary recall, which tends to systematically under-record (cf. Morrison *et al.*, 1949; Thomson, 1958; Campbell and Dodds, 1967; and Acheson *et al.* 1980); though it is sometimes just highly variable (Todd *et al.*, 1983). Only the frequency of consumption is recorded in my data and there is thus no data on the mass of the different food items.[24] The data is available only at 'kitchen' level and therefore no consideration of intra-household food distribution is possible.[25] These constraints mean that only generalised statements can be made about diet levels and differences.

In Shona 'culture' meals are equated with **sadza**, which is virtually a synonym for food (Tumwine, 1989). People often say that they live only on **sadza** and rape or greens. The data below indicate how misleading this picture is. The two previous detailed studies of Shona diet also emphasise the variety in meal types (Duncan, 1933:103); Madovi (1982) states: 'Cereals account for the largest portion of the diet and are prepared in several ways to relieve monotony'.

4.3.1 PATTERNS OF CONSUMPTION OF MAIN MEALS

Table 4.3.1.1 presents data on seasonal and inter-annual differences in the frequency of consumption of different main meal types for the boundary and clayveld populations.

Differences between main meal types between the ecological zones

The boundary population consumes more meals than does that of the clayveld. This was especially true in the post-harvest period in 1987. A higher level of consumption of **sadza** meals was found in the boundary population. This accords with some higher flour consumption estimates for the boundary population (4.2.3.2 and 4.2.3.3).

TABLE 4.3.1.1 CONSUMPTION OF MAIN MEAL TYPES

	BOUNDARY POPULATION								CLAYVELD POPULATION								TOTAL	
	Dry season				Post-harvest				Dry Season				Post-harvest					
	Wealthy		Poor		Wealthy		Poor		Wealthy		Poor		Wealthy		Poor			
H/hold days	n=21		n=42		n=14		n=34		n=49		n=28		n=33		n=34		n=255	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total meals	82		157		89		144		158		92		137		122		981	
Meals/hh/day	3.9		3.7		6.4		4.2		3.2		3.3		4.2		3.6			
Sadza meals	49	60	73	46	34	38	70	49	73	46	37	40	43	31	54	44	433	44
Other main meals	5	6	25	16	2	2	8	6	37	23	16	17	12	9	9	7	114	12
Bread meals	19	23	34	22	44	49	24	17	32	20	28	30	21	15	24	20	226	23
Direct produce	0	0	11	7	9	10	30	21	7	4	2	2	56	41	29	24	144	15
Porridges	3	4	0	0	0	0	0	0	7	4	7	8	4	3	5	4	26	3
Eggs (meals only)	3	4	3	2	0	0	7	5	0	0	0	0	0	0	0	0	13	1
Wild fruits (meals)	3	4	11	7	0	0	4	3	2	1	2	1	1	1	1	1	24	2
Honey (meals only)	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0

Notes to Table 4.3.1.1:
Dry season refers to August/September 1986 and post-harvest to March 1987.

Wealthy and Poor are defined as in Table 4.1.1.

H/hold days refers to the number of days for which there are records for kitchens in this category. For example seven days each for three households is 21 H/hold days

Meals were distinguished from other consumption events (for which data was also collected), by the criteria that 'meals' are collective events and take place within the home.

Sadza meals are those that comprise a stiff porridge made of flour with a relish. Direct produce refers to farm products eaten in an essentially unprocessed form such as boiled maize cobs, or chewed sweet reeds.

A detailed breakdown of the food types composing each category is presented in Tables 4.3.2.1, 4.3.3.1, and 4.3.5.1.

A further contribution to greater frequency of meal consumption in the boundary population was the use of gathered fruits as meals (see Section 4.3.5). The clayveld population apparently made more use of other types of 'main meal' (see Table 4.3.3.1 for a breakdown of these other meal types). Differences in other meal categories were more variable. This overall difference in consumption suggests that the boundary population may indeed have a better diet, even though they apparently produced less cereals (Section 4.2).

Differences in main meal types between wealthy and poor wealth categories

Wealthy households apparently ate marginally more frequently than did the poor. This was most marked in the boundary population in the post-harvest period. More frequent meals does not necessarily mean higher absolute intake of energy and/or specific nutrients, as meal size may also vary. More frequent meal preparation may be an effect of the wealthy having larger average household size (Section 4.1) making an economy of scale so that more, but smaller meals are cooked. Any such practice would not have equal impact on adults and children, as the young could capitalise on more frequent meals enabling them to overcome the constraint of stomach capacity.

There are no systematic differences in the meal composition of poor versus wealthy households. In the boundary population the wealthy more frequently consume bread, whilst the poor more frequently consume direct produce, other main meals and wild fruits. In the clayveld population the reverse is seen (except for wild fruits which are insignificant as meals in this zone). In both zones the dry season was a time of higher **sadza** consumption by the wealthy, whilst the post-harvest season saw more consumption amongst the poor.

Seasonal changes in main meal types

The post-harvest season in most agricultural societies is characterised as the time of maximal food availability (eg. for Zimbabwe see Caron *et al.* 1988:76-7). Table 4.3.1.1 does show that there were more meals consumed per day after harvest than in the dry season, especially by wealthy households. Changes in main meal composition also occurred with season. The most marked difference was a (not surprising) high level of consumption of direct agricultural produce in the post-harvest period. This availability may compensate/cause general reductions in the frequency of the other meal types, including **sadza** 'stiff porridge' and the other cereal and produce based main meals.

Bread meals are more frequently consumed in the boundary population in the post-harvest than dry season, whilst the reverse was the case in the clayveld sample. The reason for this difference is unknown. Wild fruit meals are especially consumed during the dry season (see Section 4.3.5).

4.3.2 Relish Use

Table 4.3.2.1 examines seasonal relish use contrasts between wealth categories and ecological zones.

Differences in relish use between the ecological zones

There was not much overall difference in relish use between the ecological zones either for animal or vegetable relishes. Fish consumption is more frequent in the clayveld zone; this is probably a function of the proximity of the river Runde (see Appendix One for discussion of fish availability).

Differences in relish use between wealthy and poor household categories

Overall the frequency of animal protein consumption is higher in wealthy than poor households, but not statistically significantly so. Considering only animal meat consumption, the richer households do eat significantly more and the difference is especially marked in domestic slaughterings of goats. Milk is consumed more frequently by the wealthy, but the effect is not quite statistically significant at the 5% level. The contrasts in the levels of meat and milk consumption between the wealthy and poor and much less marked than the differences in their livestock holdings (as documented in Section 4.1). This probably reflects both the extent of inter-household 'sharing' and the elasticity of spending on meat relish. There is no evidence for the poor milking their animals harder to compenstate for fewer stock as reported for Maasai by Grandin (1988). Fish consumption is notably more frequent amongst the poor in the clayveld sample, and partly compensates for lower consumption of domestic meat, and is a further factor in minimising differences in animal protein consumption by wealth.

TABLE 4.3.2.1 RELISHES CONSUMED WITH SADZA DISHES

H/hold days	BOUNDARY POPULATION Dry season Wealthy n=21		Poor n=42		Post-harvest Wealthy n=14		Poor n=34		CLAYVELD POPULATION Dry Season Wealthy n=49		Poor n=28		Post-harvest Wealthy n=33		Poor n=34		TOTAL n=255	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Sadza meals	49		73		34		70		73		37		43		54		433	
Relish types:																		
Chicken	5	10	8	11	5	15	1	1	12	16	2	5	3	7	3	6	39	9
Goat	9	18	3	4	1	3			6	8	2	5	1	2	1	2	23	5
Cattle	1	2	1	1					1	1							3	1
Sheep									1	1			1	2			2	0
Game			2	3													2	0
Unident.	1	2	6	8	1	3	9	13					1	2	1	2	19	4
Fish (local)	1	2	1	1	5	15	11	16	4	5	5	14	6	14	18	33	47	11
Fish (import)			1	1	2	6							1	2			4	1
Termites			1	1													1	0
Eggs			1	1	1	3	1	1	2	3	3	8					8	2
Milk (sour)	10	20	5	7			7	10	14	19	4	11	10	23	4	7	51	12
Lacto			1	1											1	2	2	0
Milk (fresh)			1	1			3	4	1	1							2	0
Animal protein:	27	55	31	42	15	44	32	46	41	56	16	43	23	53	28	52	203	47
Unamed leaf veg	4	8	31	42			20	29					3	7	2	4	60	14
Rape	14	29	4	5	1	3			28	38	11	30					58	13
Cabbages	3	6							9	12	6	16					18	4
Tomatoes plus															2	4	2	0
Potatoes													2	5			2	0
Cucurbit					4	12	3	4					5	12	8	15	20	5
Cow pea					5	15	1	3	2	3			4	9	6	11	18	4
Cleome gynandra			2	2	4	12	5	7	1	1	3	8	5	12	4	7	20	5
Cucumis myriocarpus															1	2	1	0
Derere			1	1	6	18	1	1									8	2
Mupombera															2	4	2	0
Total Leaf veg:	21	42	37	51	20	59	30	43	40	55	20	54	19	44	25	46	208	48

TABLE 4.3.2.1 RELISHES CONSUMED WITH SADZA DISHES: CONTINUED

H/hold days	BOUNDARY POPULATION Dry season Wealthy n=21		Dry season Poor n=42		Post-harvest Wealthy n=14		Post-harvest Poor n=34		CLAYVELD POPULATION Dry Season Wealthy n=49		Dry Season Poor n=28		Post-harvest Wealthy n=33		Post-harvest Poor n=34		TOTAL n=255	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Beans	3	6	3	4							1	3			1	2	8	2
Sweet potatoes			2	3													2	0
Sugar															3	6	3	1
G'nuts (dakadaka)			2	3			4	6									6	1
Cucurbit seeds													2	5			2	0
Relish unknown			4	5			4	6									4	1
Total Other Relish	3	6	11	15	0	0	8	11	0	0	1	3	2	5	4	8	25	6

Notes to Table 4.3.2.1:
Wealthy and poor and season categories are defined as in 4.1.1.
Some of the totals add up to over 100% due to some multiple relish use.

Imported fish are matemba, which are small sardine-like freshwater fish from the Kariba dam on the Zambian border, and possibly from other Central African lakes. Lacto is a sour milk produced by the Zimbabwe Milk Marketing Board. Dakataka is made from roasted ground nuts made into butter, and then boiled with water and salt. Cucurbit seeds prepared in the same way, and called dovi remhunzi

Differences by ecological zone
Local fish consumption is more frequent in the clayveld than boundary population χ^2 (1df) = 6.61, $p<0.02$

Wealth differences
Animal protein consumption is more frequent in wealthy than poor categories; χ^2 (1df) = 2.44 $p<0.2$ ns
Meat consumption is more frequent in wealthy than poor categories; χ^2 (1df) = 4.20 $p<0.05$
Milk consumption is more frequent in wealthy than poor categories; χ^2 (1df) = 3.72 $p<0.1$ nearly equal 0.05
Local fish consumption is more frequent in poor than wealthy categories in clayveld; χ^2 (1df) = 9.27 $p<0.01$

Seasonal differences
Meat consumption is more frequent in the dry than post-harvest seasons; χ^2 (1df) = 8.62 $p<0.01$
Fish consumption is more frequent in the post-harvest than dry seasons; χ^2 (1df) = 25.6 $p<0.001$
Rape and cabbage is more frequent in the dry than post-harvest seasons; χ^2 (1df) = 74.2 $p<0.001$. (The poor in the boundary population were excluded from this analysis as there was too high an incidence of 'unamed vegetables'.)
Cucurbit, cow pea, *Cleome gynandra*, *Cucumis myriocarpus*, derere, and mupombera are consumed more frequently in the post-harvest season; χ^2 (1df) = 31.2, $p<0.001$. (The poor in the boundary population were excluded from this analysis as there was too high an incidence of 'unamed vegetables'.)

Seasonal changes in relish use

Meat consumption is most frequent in the dry season; whilst in the post-harvest season there is greater consumption of fish. This tends to balance animal protein intake between the seasons. But it is likely that animal protein intake is much lower in the rains (as it is in northern Malawi, for example, see Nurse, 1975). Milk consumption levels did not vary much between the post-harvest and dry seasons in this sample. This is thought atypical as people tend to say that milk production falls in the dry season (as it does in other semi-arid area pastoral systems, eg. where milk yields can be three times as high at the end of the rains as in the dry season.[26]

Leaf vegetable consumption shifts between dry season consumption of rape and cabbage (which are cultivated in dambo and river-side gardens: see Chapter Three, Section 3.4); and post-harvest consumption of the rainy season vegetables: cultivars such as cucurbits and cow peas, weeds such as *Cleome gynandra* and **derere**, and wild plants such as **mupombera**. Appendix One details leaf vegetable consumption by species in this region.

It is unfortunate that there is no wet season meal composition data for 1986-7 (data collected in 1989 have not yet been analysed). Such rainy season records would draw attention to the importance of various wild greens, especially weeds, and also other gathered plants. Table 4.3.2.2 shows the frequency of reports of various relish plants from women interviewed in the dry season of 1986 and asked to identify the general (year-round) most important plant relishes.

Differences in ecological diversity in gathered relish plants between zones

Table 4.3.2.2 suggests that the diversity of food plants regularly eaten is greater in sandveld (and the sandveld-using boundary sample) than in clayveld. This is related to the much higher diversity of plants (and edible plants) in this zone (Chapter Three, Appendix One). The edible fungi that are associated with certain miombo trees and termite species make an important contribution to the diversity of food plants on sandveld. Due to the severe drought in 1986-7 there were not many fungi available. However, in wetter 1987-8 people were seeing coming with sacks full of Cantharellids from the patches of forest in the hills.

Table 4.3.2.2 Relish plants mentioned as important by women by zone

Species	Sandveld N. women = 7 Percent mention	Boundary N. women = 14 Percent mention	Clayveld N. women = 23 Percent mention
CULTIVAR LEAF VEG			
Cucurbits	57	93	100
Vigna unguiculata	43	93	83
GATHERED LEAF VEG			
Cleome gynandra	86	93	100
Mupombera		43	48
Cucumis myriocarpus	71	29	43
Mudyamvuu	14	4	36
Corchorus spp.		29	4
Muvhunzandadya		14	
Sonchus oleraceus		7	
Cucumis metuliferus		7	
Nhori	14	7	
Asclepias densiflora		7	
Cleome monophylla		7	
Cocculus hirsutas	14	7	
Adansonia digitata		7	
Amaranthus graecizans	14	7	
FUNGI			
Chihombiro	43		
Chikadzimaba	14		
Dindindi		7	
Muchochororo wejongwe	14		
Nhedzi	43		
Ushaveshave	43		
Uzvukwezvukwe	14		
Zheve yambuya	29		
Total N. ethno-species:	15	17	7

Notes to Table 4.3.2.2:
Identifications and common names for these food plants are found in Appendix Four. Descriptions of their use and ecology are given in Appendix One

As women named many species as important, totals add up to well over 100%

Special cautions on data in Table 4.3.2.2
Table 4.3.2.2 is based solely on the frequency of 'mentions' as being an important relish plant, and this by a variable number of women. It can be expected that the number of plants mentioned varied with changing interviewer and womens' attitudes quite independently of any real variations in use. Propensity to mention will also not necessarily reflect frequency or amount of consumption. Nevertheless the results are sufficiently marked to be worth interpreting.

4.3.3 Composition of Other Meals

Table 4.3.3.1 presents data on the composition of other categories of meals, allowing contrasts to be drawn between seasons, ecological zones, and wealth categories.

TABLE 4.3.3.1 COMPOSITION OF OTHER MEAL CATEGORIES

	BOUNDARY POPULATION								CLAYVELD POPULATION								TOTAL	
	Dry season				Post-harvest				Dry Season				Post-harvest					
	Wealthy		Poor		Wealthy		Poor		Wealthy		Poor		Wealthy		Poor			
H/hold days	n=21		n=42		n=14		n=34		n=49		n=28		n=33		n=34		n=255	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Other main meals	5	6	25	16	2	2	8	6	37	23	16	17	12	9	9	7	114	12
types;																		
Mangayi			2	8			2	25	10	27	3	19	2	17	3	33	22	19
Nhopi	2	40	8	32	1	50	1	13	7	19	3	19	5	42			27	24
Mutakura	3	60	2	8	1	50			5	14	4	25	2	17	2	22	19	17
Mashakada			6	24			5	63	6	16	2	13	2	17	2	22	22	19
Mudhigidhi			5	20					6	16	4	25					15	13
Mutongoza			1	4													1	1
Maputi									1	3							1	1
Rice			1	4					2	5			1	8	2	22	6	5
Direct produce	0	0	11	7	9	10	30	21	7	4	2	2	56	41	29	24	144	15
Crop types;																		
Pumpkins			5	45			3	10	4	57	2	100			4	14	18	13
Sweet potatoes			5	45					3	43					1	3	9	6
Sweet sorghum					3	33	4	13					7	13	3	10	17	12
Water melons					2	22	6	20					17	30	10	34	38	26
Groundnuts			1	10	2	22	7	23					10	18	1	3	21	15
Roundnuts					1	11	2	7					9	16	2	7	14	10
Maize cobs					1	11	8	27					13	23	8	28	30	21
Bread meals	19	23	34	22	44	49	24	17	32	20	28	30	21	15	24	20	226	23
Bread types;																		
Wheat bread	15	79	13	38	27	61	13	54	10	31	8	29	15	71	11	46	112	50
Makere	2	11	13	38	13	30	9	38	10	31	10	36	6	29	13	54	76	34
Makeke			3	9	4	9	1	4	4	13	8	29					20	9
Zvifutura	2	11	5	15			1	4	8	25	2	7					18	8

For notes and definitions see adjoining page.

Notes to Table 4.3.3.1:
Definitions of meals:
Mangayi: (= magwadya) whole maize grains boiled until soft
Nhopi: cooked pumpkin mash prepared with cereal flour and sometimes groundnut butter and sugar
Mutakura: boiled whole round nut and/or cow peas together with boiled whole maize seeds
Mashakada: (= matyakada) maize grains are pounded to break them into pieces and then boiled and groundnut butter added
Mudhigidhi: cooked whole maize grains are prepared in pumpkin mash, sometimes with sugar
Mutongoza: boiled whole grains of sorghum (usually white)
Maputi: whole maize grains are dry roasted on a metal plate over a fire
Rice: usually purchased, but also grown in sandveld dambos. Boiled in water.

Wheat bread: this is purchased from stores and baked by three bakeries in nearby towns
Makere: (= makerengwani) this is prepared from local cereal flour (and occasionally purchased wheat flour), with salt and sometimes sugar. Boiling water is added and the 'bread' cooked dry by boiling over fire.
Makeke: local cereal flour is usually combined with purchased wheat flour, and generally eggs and a little salt and sugar are used. A little oil can be added, at least to coat the pan. The 'bread' (cake) is cooked by covering the pan with burning embers.
Zvifutura: (= mafetikuku, zvitumbuwa or mabhanzi) purchased wheat flour mixed with sugar, a bit of salt and sometimes eggs. They are then deep fried in purchased vegetable oil.

Another meal eaten in the area but not recorded in this particular sample:
Bwirebwire: bulrush millet is roasted and ground very fine with salt and sugar. It is taken on journeys as a mupako or mbuva (a 'lunch-box')

Statistical analysis of contrasts in bread use
The bread of wealthy households is more frequently commercial wheat than that of the poor: χ^2 (1df) = 6.41, $p<0.02$
Wheat bread is a more frequent component of bread meals in the post-harvest than dry seasons: χ^2 (1df) = 7.08, $p<0.01$
Homemade wheat breads (makeka and zvifutura) are more frequently consumed during the dry season: χ^2(1df)=21.4 $p<0.001$
Makere is more frequently consumed by the poor than the wealthy; χ^2 (1df) = 5.08 $p<0.05$

It has already been demonstrated (Section 4.3.2) that 'other meals' are more frequent in the dry season and that direct produce is more frequently consumed during the post-harvest season. The high frequency of consumption of these other meals and the range of types involved makes clear what great variety there is in the diet. These two categories of meal tend to complement eachother seasonally to maintain diversity in the diet. Pumpkins and sweet potatoes are direct produce which can be stored sufficiently to last through to the dry season, which is why they are still eaten then.

Breads (mainly eaten at 'breakfast') are also clearly important in the diet; they are involved about a quarter of meals.[27] It is the wealthier households that consume the most wheat bread, whilst the poor consume the **makere** of local cereals, which is viewed as 'lower class'. Purchase of ready-made wheat bread is more frequent during the harvest season, when people are still busy, than in the dry season when there is more time for the making of homemade wheat breads.

4.3.4 Drink Consumption

Table 4.3.4.1 presents data on the frequency of consumption of various drinks. Drinks of considerable nutritional content are consumed in large quantities in both wealthy and poor households, and in both ecological zones and seasons. There are actually few marked differences between population sectors and seasons.

Tea is drunk equally often by the wealthy and poor, and an average of once per day (number of cups not quantified). However, the wealthy more frequently consume it with milk. Yet even the 'poor', owning very few cattle, manage to consume most of their tea with milk. This is partly achieved by using goat milk, which is also used by some of the 'wealthy', though it is considered slightly embarrassing and low status. People generally claim that goat milk consumption started only recently, but this is probably not the case. 'Poor' households also gained access to cattle milk through purchase and, more important, as part of their stock-sharing relationships (see Section 4.1).

Maheu (sweet beer) is particularly important nutritionally as it has high nutrient content and is consumed in the long gaps between meals and during periods of work. There were no overall differences in consumption by wealth category, except that on average sorghum is somewhat more frequently used by the wealthier households. This may reflect chance effects of household preferences. **Maheu** consumption is more frequent in the boundary than clayveld population. This may partly reflect the close lineage-related inter-household ties of labour and co-operation in this sample (Section 4.1), whereby it is shared/brewed more often.

On average alcoholic beer is consumed by at least one person in a household on between one day in thirty and one day in seven. However, for some individuals it is consumed in such large amounts that it virtually replaces other cereal intake. Consumption of beer is more frequent amongst the relatively poor in the boundary population sub-sample.[28]

TABLE 4.3.4.1 FREQUENCY OF CONSUMPTION OF DRINKS

	BOUNDARY POPULATION								CLAYVELD POPULATION								TOTAL	
	Dry season				Post-harvest				Dry Season				Post-harvest					
	Wealthy		Poor		Wealthy		Poor		Wealthy		Poor		Wealthy		Poor			
H/hold days	n=21		n=42		n=14		n=34		n=49		n=28		n=33		n=34		n=255	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
TEA																		
With milk	22	105	36	86	16	114	29	85	38	78	19	68	27	82	26	76	213	84
No milk	3	14	21	50	13	93	33	97	6	12	11	39	5	15	9	26	101	40
MAHEU																		
Maize	5	24	9	21	6	43	15	44	13	27	8	29	4	12	8	24	68	27
Bulrush millet	6	29	11	26	6	43	16	47	16	33	9	32	5	15	3	9	72	28
Sorghum	3	14	1	2	5	36	1	3	5	10	1	4	0	0	0	0	16	6
Finger millet	0	0	0	0	0	0	0	0	1	2	2	7	0	0	0	0	3	1
MUTAMBIZA	0	0	0	0	0	0	0	0	0	0	2	7	0	0	1	3	3	1
MASVUSVU	0	0	0	0	0	0	0	0	0	0	1	4	0	0	1	3	2	1
MUKUMBI	0	0	0	0	0	0	7	21	0	0	0	0	0	0	1	3	8	3
MINERALS	1	5	2	5	1	7	0	0	2	4	1	4	0	0	0	0	7	3
BEER	4	3	25	16	5	5	13	10	10	3	8	6	9	5	9	5	83	6

Notes to Table 4.3.4.1:
'Wealthy' in this table means membership of wealth ranks 1 and 2; while poor is defined as wealth ranks 3 and 4
Dry season refers to August-September 1986; post-harvest season refers to March 1987

Tea was mainly made with actual 'tea' but also includes infusions with indigenous leaves, such as *Combretum hereroense*, coffee, and a tea-like liquid made from burnt sugar residue. 'With milk' actually includes some cases where groundnut butter is used, as this has a similar nutritional content. 'No milk' includes cases where lemon juice has been added. Tea is invariably drunk with large quantities of sugar; when there is no sugar available tea is not prepared.

A higher frequency of the tea drunk by the wealthy was with milk than that drunk by the poor. χ^2 (1df) = 14.3, p<0.001

Maheu is a form of non-alcoholic drink, the bulk of which is generally made from left over sadza (stiff porridge). Malt (grains soaked for several days) are ground and added, and the mixture as a whole left to ferment for one day.
Sorghum is more frequently consumed as maheu in the wealthy than poorer kitchens; χ^2 (1df) = 6.38, p<0.02
Mutambiza, is an industrial form of maheu purchased in stores
Masvusvu, a form of maheu, where malted grain is ground and boiled

Notes to Table 4.3.4.1: (Continued)
Mukumbi, which is made from the fruits of *Sclerocarya birrea*. The thick fruit skins are removed and water added to the fruit in a container when it is left for the required number of days. More than three days makes it highly alcoholic. The mixture is sieved before serving. The seeds may by put aside for later removal of the fatty embryo (see Appendix One)
Minerals refers to bottled mineral drinks with international trademarks, and a sweet orange squash produced industrially in central Africa.

Beer % are expressed as a proportion of adult-days, where adults are defined as those over twenty years old attached to that kitchen in the demographic survey.

In the boundary sub-sample beer is consumed more frequently by adults in poor than wealthy kitchens/households, χ^2 (1df) = 14.91, p<0.001

4.3.5 Quantitative Data on the use of Gathered Produce

Detailed discussion of the use of gathered and wild foods is given in Appendix One, which establishes how important they are in the general diet and economy. Unfortunately it proved difficult to obtain quantitative measures of actual intake of such foods, and even general estimates of the importance of specific foods have been difficult to make. This section examines some data for wild fruit consumption, and then looks at more general records of other gathered food use.

Wild fruits

Table 4.3.5.1 shows the number of fruit meals consumed per day by 'wealthy' and 'poor' households, in the different seasons and ecological zones. The term 'meals' refers to consumption events where several (usually all) members of the household together eat a substantial amount of prepared food at the home. People recording their food consumption for themselves clearly differentiated these events from the more common snacking on fruits. Some of these meals were 'supplementary' to the basic two large meals a day, whilst others clearly replaced a 'standard' **sadza** meal.

The data in Table 4.3.5.1 suggest that fruit consumption as meals is more frequent in the boundary population, and in the dry season. This is what is predicted in terms of ecological dynamics (Chapter Three). It also appears that the use of fruits as meals is more important amongst the relatively poor.

Table 4,3,5,1 Fruit Meal Consumption by Zone

	Boundary						Clayveld					
	Wealthy			Poor			Wealthy			Poor		
	N HH/	Meals		N HH/	Meals		N HH/	Meals		N HH/	Meals	
	days	n	%	days	n	%	days	n	%	days	n	%
Dry season	21	3	14	42	11	26	49	2	4	28	2	7
Post-harvest	14	0	0	34	4	12	33	1	3	34	0	0

Notes to Table 4,3,5,1:
Dry season is Aug-Sept 1986
Post-harvest is March 1987

For definitions of wealth categories and HHold days see 4,1,1

During the dry season (Aug-Sept) boundary populations consume more fruit meals than clayveld populations;
$\chi^2 = 8.97$, 1df, $p<0.01$
Boundary populations consume more fruit meals in the dry season (Aug-Sept) than post-harvest season (Mar);
$\chi^2 = 3.87$, 1df, $p<0.05$
The boundary population poor may consume more fruit meals than the boundary rich, $\chi^2 = 2.19$, 1df, $p<0.2$ only, n.s.

Table 4.3.5.2 shows the contribution of different tree fruit species to individual consumption-events (inside and outside the home) by season and ecological zone. The range of fruit trees indicated is a small subsample of the total range used because sampling at two discrete time intervals intersected only a few fruiting phenologies. A full list of fruits eaten and their seasonality is found in Appendix One. Although the diversity of fruit trees available to the sandveld and boundary populations is much greater than that for the clayveld households (Chapter Three, Appendix One), a similar variety of trees used were recorded in Table 4.3.5.2. This is probably an artifact of larger sample size (number of household days) on clayveld. The trees important in clayveld are those associated with specific micro-environments (termitaria, rocky outcrops and river banks): *Diospyros mespiliformis*, *Azanza garckeana*, *Grewia flavescens* and *Vangueria* spp. Other fruit eaten by clayveld people was actually picked in sandveld areas, but was always consumed infrequently and reportedly in very small quantities (eg. *Ficus* spp., *Flacourtia indica* and *Strychnos madagascariensis*). In the boundary population it is the sandveld trees that are most important, along with trees from clayveld micro-environments.

4.3.5.2 Indigenous fruit consumption by species: within and outside the home

	Boundary				Clayveld			
	Dry Aug-Sept		Post-Harv March		Dry Aug-Sept		Post-Harv March	
N HH/days:	63		48		77		67	
	n	%	n	%	n	%	n	%
Diospyros mespiliformis	23	37	1	2	25	32	2	3
Azanza garckeana	19	30			8	10	1	1
Ficus soldanella	6	10	1	2	1	1		
Ficus sycomoros	2	3						
Adansonia digitata	2	3			1	1	2	3
Flacourtia indica	2	3	3	6				
Ziziphus mucronata			2	6	3	4	2	3
Mimusops zeyheri	1	2						
Strychnos madagascariensis					1	1		
Rhus spp.					1	1		
Berchemia spp.			16	33			18	27
Artabotrys brachypetalus			7	15				
Sclerocarya birrea (fruit)			3	6			1	1
mukumbi (drink)			7	15			1	1
Euphorbia matabelensis			2	4				
Vitex spp.			2	4				
Lannea discolor			1	2			1	1
Grewia spp.			1	2	2	3	1	1
Grewia flavescens			1	2	1	1	7	10
MuNhorido			1	1				
Ficus sur							1	1
Vangueria spp.							8	12
Exotic fruits	1	2	2	4	1	1		
Total cons. indig	55	87	48	100	44	57	48	72
Number species	7		13		9		12	

Notes to Table 4.3.5.2:
N and % are of the number of household days in that category in which one or more people were recorded as consuming fruits of that species.

It was not possible to separate consumption by poor versus rich households as the proportion of households consuming fruit is not independent of the number of individuals and household age-sex composition, which could not be controlled for in such a small sample.

The number of species eaten in each zone cannot strictly be compared as the number of household days (ie. sample size) differs between them.

Indigenous fruits are eaten more frequently in the post-harvest than the dry season in both zones. The boundary population cannot be legitimately tested with χ^2 as two expected values are below 5 due to the high level of fruit consumption in this zone. In the clayveld sample the difference is not significant (χ^2= 3.27, 1df, p<0.1).

Fruit is consumed more frequently by the boundary than clayveld population in both the dry and post-harvest seasons (seasons combined), χ^2= 23.03, 1df, p<0.001

Consumption of fruits was more frequent in the boundary population than that in the clayveld (Table 4.3.5.2). The sandveld zone supports more fruit trees of the types with highly nutritious and tasty fruits (Chapter Three, Appendix One). A true sandveld sub-sample in this survey would have been very valuable for full comparison. Exotic fruits provided a negligible contribution to these particular homes at the times of survey; these tend to fruit during the rainy season. (For densities of these exotic trees in homes see Appendix One.)

There were more fruit consumption events in the post-harvest than the dry season in both zones; though this could not be proven statistically. In Appendix One phenological data is presented to suggest that there is more fruiting after the rains, especially in the clayveld zone. However, in the boundary population the total amount consumed is greater in the dry season, although fruit is eaten more frequently in the post-harvest period (Table 4.3.5.1). Parallels can be drawn in other dietary surveys (Appendix One; de Garine and Koppert, 1988:218) demonstrating the way in which dry season fruiting in the sandveld/sub-humid savannah system, seasonally stabilises nutritional intake.

Other Gathered Foods

Table 4.3.5.3 presents data on other gathered food stuffs. Rather than being based on semi-quantitative diet surveys, Table 4.3.5.2 shows the proportions of households that stated that they had 'consumed that food in the last year'. Detailed discussions of the use of these gathered foods can be found in Appendix One.

The frequencies of consumption of gathered products are lower than I had expected, and suggest that on average people in only around half of the households actually consume each of these items in a year (Table 4.3.5.3). This may reflect under-recording of these somewhat shameful 'bush-foods', which are often consumed privately outside of the home. It should be noted that this particular year was an especially poor one for both caterpillars and fungi (except in December 1987 in the case of the latter). However, it may also reflect the fact that many people are no longer eating these items, for religious reasons, because they are getting harder to find, and because people have less time to gather them. (It should be noted that these particular items were chosen for the 'Economic value of woodland study' for precisely the reason that they were the main wild resources associated with woodland and threatened by deforestation).

Table 4.3.5.3 Consumption of Other Gathered Foods

Number Households	Sandveld 7		Boundary 20		Clayveld 37	
	n	%	n	%	n	%
Caterpillars	1	14	8	40	10	27
Honey	2	29	12	60	18	49
Mushrooms	5	71	12	60	17	46
Cicada	0		0		3	8

Notes to Table 4,3,5,3;
I designed this survey in consultation with the Enda research team. The interviews were conducted by Florence Shumba as part of a wider study by her of 'the economic value of woodland' for Enda-Zimbabwe in January 1988.

Caterpillars were mainly *Gonimbrasia belina*, but there was also mention of *Lobobunaea* and *Herse convolvuli*. One person reported selling in town, and four reported buying in town. One had grown the caterpillars themselves on a nearby tree from early instars found in the forest. Households belonging to the 'independent churches' claim that they never eat caterpillars due to biblical prohibitions; this is the main reason for low consumption in the sandveld sample where such religious households predominate in the sample. 1987 was a very poor year for caterpillars.

Honey was mainly that of *Apis mellifera*, but 19% of households stated specifically that they had consumed the honey of monga and 8% that of bocha (ethno-species of *Trigona* and *Melipona*) and 3% the 'honey' of *Lagioglossum* spp.

A very small proportion of the known edible fungi species (see Appendix One) were encountered in this survey. This was due to the prevailing drought conditions, when most species remain dormant. It was only in Dec 1987 that heavy rains fell. Clayveld consumption of fungi includes much obtained from foraging in sandveld. Five of the seventeen fungi consuming households in clayveld actually stated that they had collected the fungi in sandveld areas. χ^2 comparison of sandveld plus boundary versus clayveld (excluding the five cases of fungi 'importation') = 5,86, 1df, p<0,02. In the boundary and clayveld samples *Termitomyces* fungi dominate (zhouchuru; 14% had consumed this ethno-species; nhedzi, 4%; and what may be *Cantharellus miniatescens* (uzvukwe) which is usually found on termitaria or their pediments (chivamba); 18%. In the sandveld sample *Cantharellus*, *Boletus* and *Termitomyces* were important in that order.

Generally people denied consumption of cicadas (nyenze), even in the cases where the research team had observed the individuals themselves catching and consuming them prior to the rains. Consumption of this species is therefore even more underestimated than the other categories.

Special cautions on the data in Table 4,3,5,3
The figures presented here can in no way be extrapolated or treated as consumption estimates. A whole year is a long period for recall. People will frequently fail to recall accurately whether they have consumed the item or not. Furthermore there is no means to estimate how much has been consumed by those who report consuming it. The abundance of these items varies greatly year by year. 1987 was said to be a particularly bad year for caterpillars and mushrooms.

The figures do not suggest great differences in the frequency of consumption of caterpillars and honey between the zones. But as expected mushrooms were consumed more frequently in the sandveld and boundary samples than on the clayveld, due to the ecology of these species (Chapter Three, Appendix One). Those species consumed in the clayveld and boundary zones are those associated with termite mounds, rather than tree litters/rooting systems as in sandveld. Cicadas are reported consumed more frequently in the clayveld, this might reflect their particular association with *Colophospermum mopane* trees which are associated with these soils (Higgs, 1987 and Wilson 1987d).

Conclusion to Chapter Four

This chapter has forged a link between the contrasting ecologies of the sandveld and clayveld zones (Chapter Three), and the human biological variables that are examined in subsequent chapters. The chapter also introduces the contrasts in environmental relations of wealthy and poor population sectors. Data are presented on how the nature of the production system and environment are reflected in productive assets, income, and level and variability of crop production. These household economic contrasts are in turn shown to be reflected in cereal consumption and in general diet. Despite the contrasts in seasonality, inter-annual variability and between wealthy and poor, household strategies and socio-political context were found to be mediating and moderating these dynamics throughout. Nevertheless underlying and dynamic ecological processes shape the domestic economy sufficiently to warrant investigation of their effects on population, health and nutrition at a community level. Chapter Five can therefore now address seasonal and inter-annual variability in birthweight and child growth, focusing on the contrasts between the ecological zones.This is then followed by comparable examination of morbidity (Chapter Six) and demography (Chapter Seven). Only in Chapter Eight do I return to the concern with economic differentiation and how this influences the way ecological dynamics affects welfare.

CHAPTER FIVE

SEASONAL AND INTER-ANNUAL DYNAMICS IN BIRTHWEIGHT AND GROWTH

Introduction

This chapter examines evidence for seasonal and inter-annual dynamics in nutrition, investigating the hypothesis established in Chapters Three and Four that ecological productivity, and hence food supply, shows opposite seasonal stress in the sandveld and clayveld zones; and that drought years have marked effects only on clayveld, with high rainfall years depressing nutrition variables in the sandveld zone. The hypothesis is shown to be corroborated by birth weight and child anthropometric status/growth velocity data for recent years in both ecological zones. These contrasting dynamics between ecological zones in nutritional status will be followed up in investigation of morbidity (Chapter Six), and fertility and mortality (Chapter Seven). The extent to which different socio-economic groups experience different vulnerability to nutritional stress (seasonally and inter-annually) is addressed in Chapter Eight; and historical trends in nutrition are then considered in Chapter Nine.

5.1 The Dynamics of Birthweight

Introduction

Birthweight reflects maternal health, size and fluctuation in nutritional status, and in turn affects early survival and growth (Mata, 1978). This section examines seasonal and inter-annual variation in birthweight. An examination of the impact of birthweight on subsequent growth then links this section to Section 5.2 and 5.3 on growth. Relationships between birthweight and morbidity and mortality are taken up again in Chapters Six and Seven.

Sources of Data

For the in-depth Mototi sample 29 singleton birthweights with dates are known for children that were born in hospitals or clinics and had a birthweight recorded on their 'Road to Health' card. There is no bias in the proportions of children for which there are birthweights between mothers of different wealth. As demonstrated in Chapter Eight there was no relationship between wealth and birthweight in this sample. It is not known whether the sample is biased towards 'problem' births, and the degree to which this would affect birthweight. One of the birthweights was particularly low (1,98kg) and was noted as 'pre-term' by the mother. Otherwise the 10,3% of births under 2,5Kg are assumed 'small-for-dates' at 'normal' term lengths.'

Birth weights with a mean around 3kg are typical in Africa. In seven populations considered in Meredity (1970), only the Bambuti Pygmies had a significantly different (lower) weight. More recent studies have also found birth weights around 3kg (Dedza, Malawi [K. Wilson, unpublished data]; Zambia [Bhat *et al*, 1989]; and Nigeria [Ogbeide and Alakija, 1985]).

Small sex differences in birthweight were recorded, mean weight male babies was 3,25 kg and female babies 2,95 kg, such a difference is typical in Africa (eg, an area of Nigeria: Ogbeide and Alakija, 1985; Tanzania: Buersina and Mbise, 1979:16, McLaren 1959:175; and Zambia: Bhat *et al*., 1989:103).

5.1.1 Ecological factors influencing birthweight: literature review

There has been a considerable amount of research into the relationship between food supply, maternal nutritional status and birthweight. Although fat deposition starts relatively early in pregnancy most foetal growth occurs in the last trimester, and deprivation effects may be concentrated in the last month before birth (Tanner, 1978:41). Maternal nutritional status and weight gain has been shown to correlate with birthweight, both in terms of an economically/nutritionally differentiated population, and also in seasonal cycles. (Salber, 1955; Shah and Shah, 1972; Gebre-Medhin and Gobezie, 1975; Lechtig *et al.* 1972b; Lechtig *et al.* 1975; Mata, 1978; Frydman *et al.*, 1980; Reinhardt, 1980; Gueri *et al.* 1982; De Vaquera *et al.*, 1983:170; Hussein and Omololu, 1983; Gwebu, 1985:195). For example, working in Kenya Jansen *et al.* 1984:147-9 found that in low birth weight versus 'other' births, the mothers were on average 3.3cm shorter, had lower sub-scapular skin fold thickness, and weighed 3.4kg less. The marked relationship between birthweight and height means that childhood malnutrition and inter-generational factors come into play with holding birthweight down (Mata, 1978; Martorell *et al.* 1981).

Levels of food consumption in the last trimester are thus associated with birthweight. Many studies of early famines/dearths (Bergnes and Susser, 1970; Peller, 1940) and of second world war 'famines' found such an effect (Antonov, 1947, in Leningrad; Smith, 1954, in the 'Dutch Hunger Winter'; and British research in Wuppertal (FRG) which is reported in Bergner and Susser, 1970:956). Antonov (1947: 256-7) has shown through review that reductions in birth weight of the order of 100-200g had commonly occurred in European famines, though they were not observed in the UK or Germany 1914-18 when there had been no real 'hunger'. Yet a body of research looking at everyday differences in diet/maternal nutritional status and birthweight in Britain and USA (eg. Thomson, 1959) has tended to report little relationship (though not always, Burke *et al.*, 1943). This is largely due to faulty design, analysis and interpretation (Bergner and Susser, 1970). Furthermore, relationships would be expected to be much more marked at higher levels of nutritional deprivation. Diet supplementation has been shown experimentally to increase birth weight (Bergner and Susser, 1970:958; Herrera *et al.* 1980; Frydman *et al.* 1980; Prentice *et al.* 1983; Prentice and Prentice, 1988); even with only micro-nutrients in deficient London (Peoples League of Health, 1942) and Canadian populations (Ebbs *et al.*, 1941:522). The effects of supplementation are most apparent at times of severe (seasonal) shortage (Prentice *et al.*, 1983). However, in general detailed research has shown that women show a phenomenal ability to cushion the growth of the foetus from food-intake inadequacies, so that declines in birthweight are relatively slight (Whitehead, 1980:343; Prentice and Prentice, 1988).

Whilst food intake and nutritional studies must implicitly recognize that energy balance is a function of expenditure as well as intake, relatively few studies have examined impact of these two factors on birth weight in a rigorous fashion. Prentice (1980:178) did try to separate the two factors, however, noting that the time of peak energy expenditure does not match that of lowest birthweight, but Roberts *et al.* (1982) still consider increased wet season activities as having an important role in wet season birth weight suppression in this area. Yet Bantje (1983, 1987:736) considered that in the drier areas of Tanzania both high energy expenditure and lower than usual food intake responsible for the steepest fall in birthweight around the start of the rains. A final point worth noting is that there may be physiological effects of hard work in the tropics that directly affect foetal growth. Briend (1984) has drawn attention to reductions in utero-placental blood flow in women with upright posture working in hot environments.

There is also research that links maternal morbidity to birthweight. In a study in Guatemala the numbers of days ill per month during gestation was a fairly good predictor of birthweight (Lechtig *et al.*, 1972a). However, the authors believe that the effect is principally due to maternal anorexia during illness, which food consumption surveys suggested involved in the reduction of 400Kcal/day. Reinhardt (1980:132) considered that malaria played 'an important role in the genesis of low birthweight' on the basis of a review and experience in the Ivory Coast; and Bantje (1987:739) suspected that in areas of holoendemic malaria 'poor health during the long wet season is indeed the main cause of birthweight seasonality'. (See Cannon, 1958, Jelliffe, 1968, and McGregor, 1982:800 for evidence and physiological mechanisms of the impact of malaria on birthweight.) However, Prentice (1980:179) observes of the seasonal reduction in birthweight during the rainy season in the Gambia that infection levels peak a full two months after the lowest birthweight, which occurs at the time of lowest energy balance.

There has been little detailed investigation of the seasonality of birthweight in African savannah populations. Work in the moist savannah of the Gambia has led to a generally recognized depression in birthweight during the rainy season (Prentice, 1980; Roberts *et al.* 1982; Prentice and Prentice, 1988). Among Natal Africans, only female babies showed wet season depression (Salber and Bradshaw, 1952: 190). An investigation of hospital records for Tanzania (Bantje, 1987) found that birthweight was lower during the rains in all eleven stations, but that the extent of seasonal depression increased with decreasing mean annual rainfall.[2] However, the driest study site in Bantje's study received a mean of 530mm rainfall, somewhat more than my study area. Since food supply and disease environment in sandveld tend to resemble the typical pattern in moist savannah (Chapters Three and Four), it is predicted that birthweight will fall during the rains on this soil type. In contrast dry season birthweights are expected to be lowest in clayveld.

There are no rigorous studies of inter-annual variation in birthweight in Africa with rainfall or any other economic or nutritional stress factor, despite the fact that studies of famine in Europe suggest that this should be an important factor in mortality and growth. (I did observe in clinic records, however, that birthweights had fallen slightly in a part of Dedza [Malawi] since the influx of large numbers of Mozambican refugees (personal observation, 1989). Studies in Nigeria (Hussain and Omolulu, 1983) and Tanzania (Bantje, 1987) have shown little historical trend in birthweight in recent years, and Bantje (1980:11-2) has shown how birthweight varied through a series of drought and flood years in Rufiji, though due to the erratic variations it was very difficult to account for the fluctuations within a simple but rigorous framework. Bantje (1987:735) notes that there is higher inter-annual variation in birthweight in drier areas of Tanzania - suggesting a link with the relative impact of rainfall variation - but he does not demonstrate a rainfall link or analyze its causative basis.

One report from Zimbabwe (Houghton and Ross, 1953) showing that African birthweights in the capital were much lower than those of whites, alleged that this was because 'Africans in 1951 were suffering from several years of drought and their level of nutrition may have been impaired' (1953:64). Yet the droughts in question (1947, and, to a lesser extent 1949) are likely to have had a much smaller impact on urban birthweights than low African wages. A second study in Zimbabwe alleging that droughts reduce birthweight (Caron *et al.* 1988) is reinterpreted in Section 5.1.2. Zunguza (1984:45) in a study in Harare found no difference between birthweights in 1982 and 1983, which were both low rainfall years. The percentage of low birthweight babies (less than 2.5kg) was low in this study (5.9%), and it is likely that the population monitored were little affected by low rural food supply.

5.1.2 Contrasting seasonality in birthweight between ecological zones

Birthweight shows the contrast in seasonality between the two ecological zones, that has been predicted according to their seasonally contrasting disease environment and food supply (5.1.1). The sandveld sample conforms to the seasonal pattern observed in moist savannah areas, whilst the clayveld population shows a previously unrecorded pattern that is probably typical in the arid savannahs. It can be noted that a preliminary report on the Rufiji in southern Tanzania, Bantje (1982) found that though birthweight and associated maternal nutritional status was lowest in the rains, population groups facing contrasting ecologies in the valley showed rather different patterns.[3]

Table 5.1.2.1 Seasonal Contrasts in Birthweight Variation

	Sandveld-Boundary			Clayveld			Sand-Bnd v. Clay		
	n	**mean**	**$\sigma n-1$**	**n**	**mean**	**$\sigma n-1$**	**t**	**df.**	**p<**
Rains	4	2.85	0.495	6	3.31	0.284	1.67	8	0.1
Non-Rains	9	3.28	0.344	10	2.87	0.418	2.19	17	0.025
	t	df.	p<	t	df.	p<			
Rains v. Non-Rains	1.66	11	0.1	2.16	14	0.025			

Notes to Table 5.1.2.1:
Rainy season births were those occurring in Dec/Jan/Feb
Non-Rains were the remaining months.
For the effects of wealth on birthweight dynamics see Chapter Eight, Section 8.1.

Clayveld birthweights are higher in the rains than are clayveld birthweights in the post-harvest and dry season (Table 5.1.2.1). The opposite pattern is shown in the sandveld-boundary population, with higher birthweights in the non-rainy season (Table 5.1.2.1).

During the rainy season, birthweight is higher in the clayveld sample than in sandveld-boundary. Yet during the dry season, sandveld-boundary birthweights are higher than those of clayveld. (See Table 5.2.1)

The level of seasonal fluctuation in mean birthweight suggested (400g) is more than the 200-300g found in the Gambia (Prentice, 1980; Roberts *et al.* 1982; Prentice and Prentice, 1988), but is similar to that recorded by studies during famines (see below). This is despite the fact that maternal nutritional status appeared good. However, note small sample size.

5.1.3 Effect of inter-annual variability in rainfall on birthweight

Variations in rainfall could affect birthweight by three main causal mechanisms. The first is via food production (during the previous year), the second is by disease-environment (reflecting rain in the current year), the third way is through effects upon maternal agricultural work levels (rainfall in current year). Evidence for these effects is discussed in Section 5.1.1.

It is hypothesised that the importance of the each of the above variables is different in the two ecological zones, because of the contrasting relationships between rainfall and food availablity and disease environment.

Nature of the Data and Method of Analysis
In this section I apply regression analysis to birthweight data to identify the relationship with rainfall in the current year and in the past year.

The birthweight data for the study area is regressed as individual birthweights, for which there are a variable number each year between 1980 and 1987. To explain the relationship between the year of rainfall and the year of birth used in this analysis I will give an illustration. A child born between March 1982 and February 1983 will be regressed against current rainfall as that which falls over the meteorological year July 1982 and June 1983 (actually 60% of the rainfall will on average fall in December 1982 through February 1983. Previous year's rainfall would in this case refer to the year June 1981 to July 1982; but the harvest this is derived from March 1982, and feed the population until the harvest of March 1983. This method therefore fully accounts for the effect of rainfall in the past year, at the expense of attributing current-year rainfall to births born before that rainfall had fallen to about half of the births. However, it is not possible to match birth dates for both factors.

Birthweight data for Chirumhanzu is a series of nineteen years data from St Theresa's Hospital (1970-88), in which there is no historical trend. Figures were derived from a graph in Caron *et al.* 1988;78a, since the original data from this exercise have unfortunately been lost (C. Jackson, pers. comm. 1989). Each figure is a mean of twenty births for the month of January (Caron *et al.* 1988;78-9). Current rainfall is that of the season that was underway at the time. Though the season was only half way though at the time of assessment, there is believed sufficient correlation between received rain in January and overall rainfall to make the analysis valid (though not ideal). Previous year's rainfall is that which produced the harvest in March-May in the year before the January assessed, and is therefore a highly appropriate figure. Rainfall data for St. Joseph's, Chirumhanzu, was provided by Dr M. Drinkwater (pers. comm. 1989), except for the years 1979-80 and 1984-5 which are derived from Caron *et al.* 1988;6a, and 1985-6 (500mm) and 1987-8 (950mm), which are estimated from nearby stations.

The Durbin-Watson statistic was calculated for each regression to test whether existing trends in the relationship would invalidate the statistical test of the regression, and this found satisfactory.

Dr Brendan Mullan assisted me with the technical aspect of this analysis.

The results from the regression analysis between current and previous rainfall and birthweight are presented in Table 5.1.3.1, and in the Graphs 5.1.3.2 to 5.1.3.7.

Table 5.1.3.1 Relationship of birthweight to current and previous rainfall

	Chirumhanzu Sandveld	Mototi Sandveld + Boundary	Mototi Clayveld
BIRTHWEIGHT			
Mean	3.04	3.07	3.04
Standard Dev	-	0.46	0.42
N. data points	19	13	16
N. years	19	6	6
CORRELATION			
Current rainfall	-0.46	-0.44	-0.33
Previous rainfall	0.03	0.36	0.47
REGRESSIONS			
Current Rainfall			
R-Square	0.21	0.19	0.11
Anovar (F-test, 1-tailed)	0.03 *	0.07 (NS)	0.11 (NS)
B (x10^4)	2.29	8.22	7.40
SE (B) (x10^4)	1.07 \	5.11	5.69
Previous Rainfall			
R-Square	0.00	0.13	0.22
Anovar (F-test, 1-tailed)	0.45 (NS)	0.11 (NS)	0.03 *
B (x10^4)	0.16	9.00	9.75
SE (B) (x10^4)	0.12	7.01	4.96
Multiple Regression Current + Previous			
R-Square	0.24	0.35	0.22
Anovar (F-test, 1-tailed)	0.03 *	0.06 (NS)	0.10 (NS)
B Current (x10^4)	-2.55	-8.85	-2.41
SE (B Current) (x10^4)	1.34	4.81	6.57
T-test (1-tailed)	0.02 *	0.05 *	0.36 (NS)
B Previous (x10^4)	9.19	9.98	8.53
SE (B Previous) (x10^4)	1.56	6.38	6.10
T-test (1-tailed)	0.22 (NS)	0.07 (NS)	0.09 (NS)

Rainfall in previous year

It is in clayveld that droughts lead to considerable production shortfalls, and wet years to times of marked surplus. Since marked control of food supply by rainfall levels is less marked in sandveld, regressions of rainfall in previous years against birthweight are expected to be significant only in clayveld. Despite very limited data, Table 5.1.3.1 and Graph 5.1.3.2 do suggest that high rainfall in the previous year elevates birthweight in clayveld, indeed that about half the inter-annual variation in birthweight could be explained by rainfall in the previous year. The relationship is much less marked for the boundary and sandveld sample from Mototi (Table 5.1.3.1, Graph 5.1.3.3) and no relationship at all is found in the true sandveld analysis in Chirumhanzu (Table 5.1.3.1, Graph 5.1.3.4).[4]

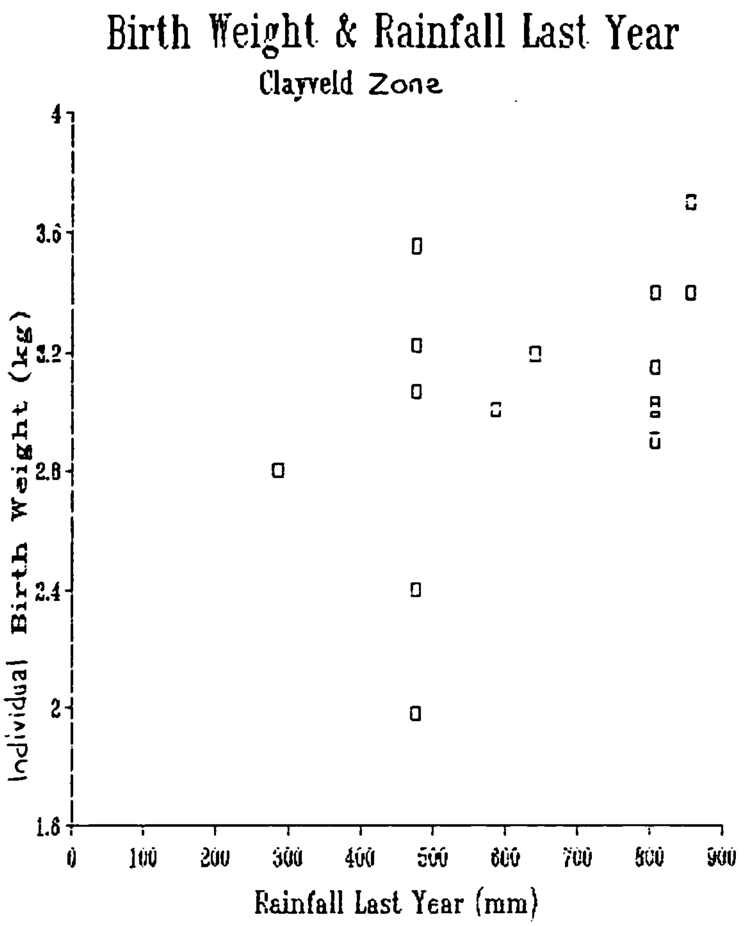


Fig. 5·1·3·2

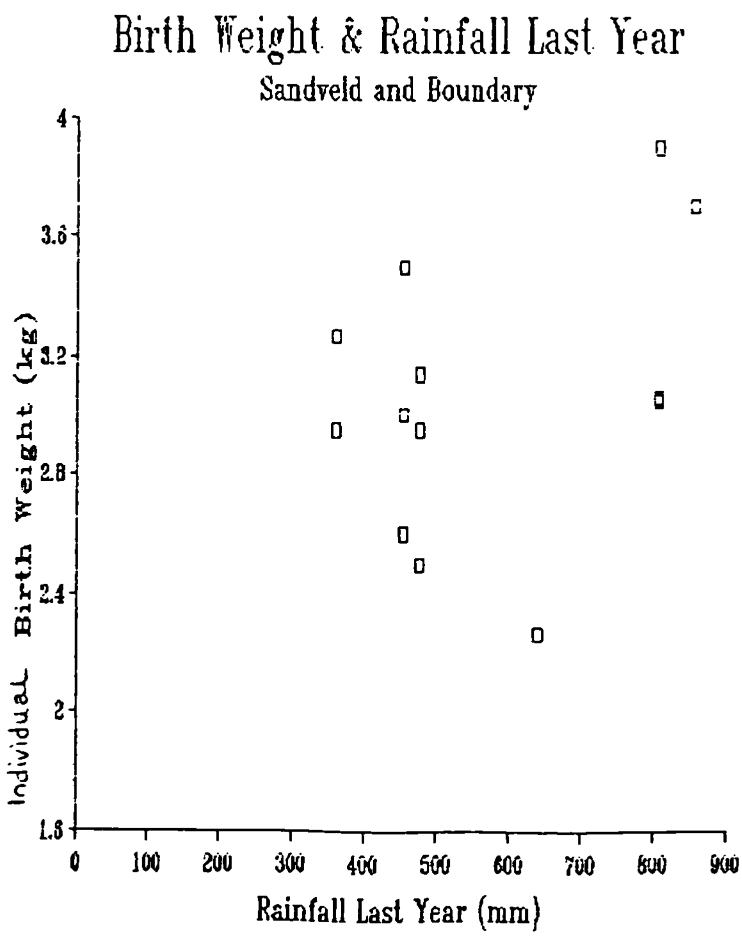


Fig. 5·1·3·3

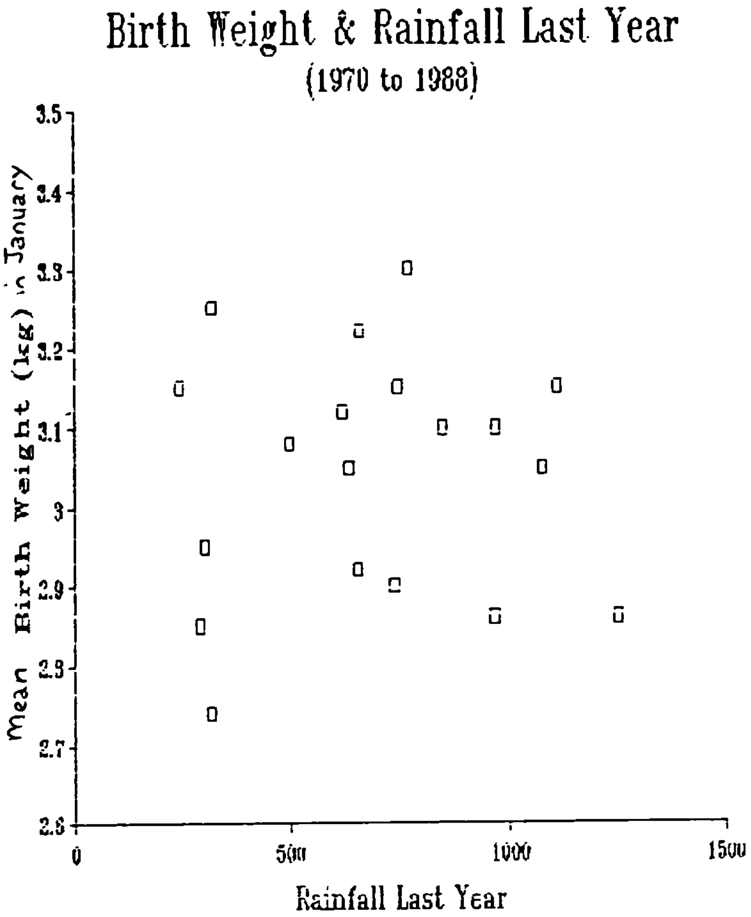


Fig. 5·1·3·4
Chirumhanzu
Sandveld

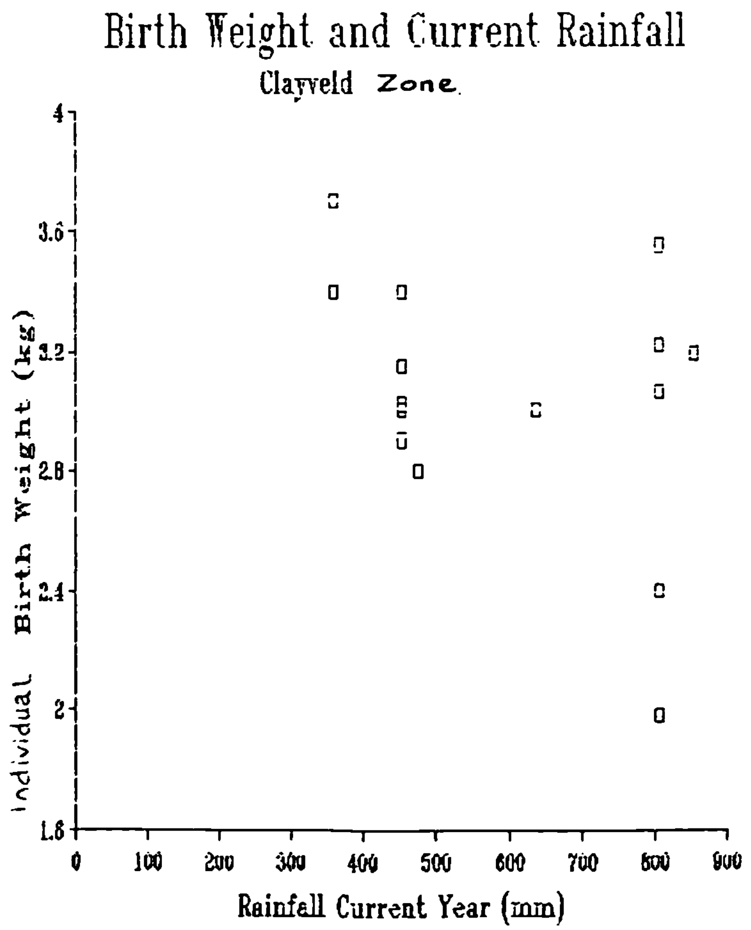


Fig. 5·1·3·5

Birth Weight and Current Rainfall

Sandveld and Boundary

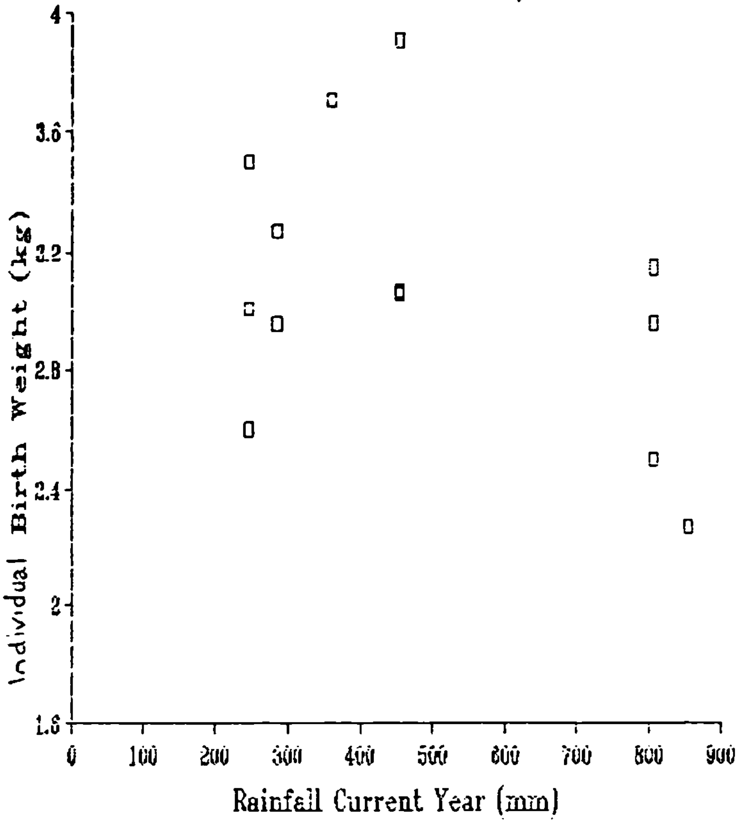


Fig. 5·1·3·6

Birth Weight & Current Rainfall

(1970 to 1988)

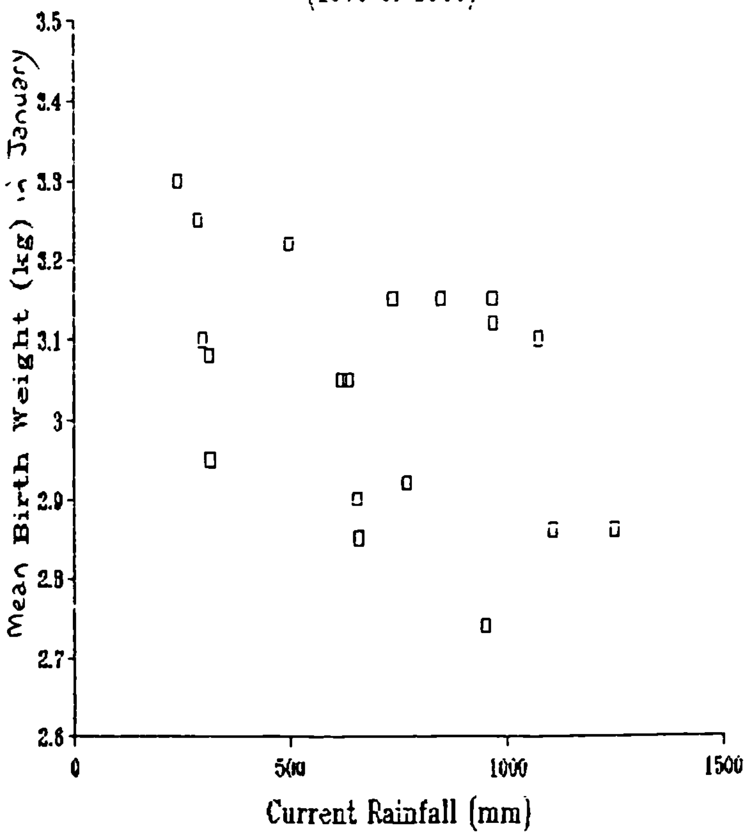


Fig. 5·1·3·7

Chirumhanzu Sandveld

Rainfall in current year

High rainfall in current year is predicted to depress birthweight through increasing maternal labour and increasing the level of morbidity. The effect is expected to be much more marked in sandveld than clayveld populations, as high rainfall worsens the disease-environment more markedly in sandveld (Chapter Three; Chapter Six). A marked and negative relationship between current rainfall and birthweight is demonstrated in sandveld (and boundary) environments in Table 5.1.3.1, and in Graphs 5.1.3.6 and 5.1.3.7. In both Mototi (sandveld and boundary) and Chirumhanzu (sandveld) around 45% of the inter-annual variation in mean birthweight could be explained by current rainfall; this result was statistically significant at the 5% level in Chirumhanzu, and almost so (0.07) in Mototi, through analysis of variance. The relationship between birthweight and current rainfall was much less marked in clayveld than in sandveld (Table 5.1.3.1, Graph 5.1.3.5), and in clayveld rainfall in current year plays less of a role in determining birthweight than does rainfall in a previous year, as was predicted.

Multiple regression

The results of multiple regression of current and previous year's rainfall are presented in Table 5.1.3.1. The result showed that in both the Mototi samples there is an interaction between current and previous year's rainfall. However, it confirmed that the effect of current rainfall on birthweight is much more significant in sandveld and boundary, and that of previous year's rainfall much more important in clayveld.

5.1.4 Effect of birthweight on subsequent size

Table 5.1.4.1 evaluates the effect of birthweight on subsequent body size. Detailed studies of large samples have shown that birthweight differences do indeed tend to persist into late childhood (Garn *et al.* 1977; Mata, 1978:158, and 321), but the effect is minimal. An African field study has also found a link between low birthweight and 'failure to thrive' in childhood (Morley *et al.* 1968:181).

The very limited data evaluated in this study suggest that there may also be an association between birthweight and subsequent weight-for-age in this sample, but any effect appears small.

Table 5.1.4.1 Weight-for-Age of Children (Age Two to Ten Years) of Relatively High and Low Birthweight

	n	mean	σn-1
Birthweight under/= to 3Kg	5	78.95	10.48
Birthweight over 3Kg	6	81.60	5.88
	t= 0.48, 9 df., non-sig		

Notes to Table 5.1.4.1:
Weight-for-Age was assessed using NCHS standards, on a September 1986 timeline (or nearest month within three months). Children from all ecological zones pooled. Only children over two years old at the timeline considered.

5.1.5 Impact of season of birth on subsequent growth

Contrasting birthweight seasonalities, perhaps combined with differential seasonalities in early growth, may result in different growth achievements by children born at different times of year. Table 5.1.5.1 examines this hypothesis for clayveld and sandveld/boundary populations in Mazvihwa.

Table 5.1.5.1 Impact of Season of Birth on Growth Attainment

	Height-for-Age			Weight-for-Age		
	n	mean	σn-1	n	mean	σn-1
Clayveld:						
Rains/Harvest	29	94.1	3.62	29	85.5	9.41
Dry	24	95.8	3.64	23	90.2	10.45
	t= 1.69, 51df, p<0.05			t= 1.67, 50df, p=0.05		
Sandveld/Boundary:						
Rains/Harvest	30	94.1	4.34	32	87.7	12.81
Dry	28	95.1	5.46	31	88.0	11.40
	t= 0.82, 56df, non-sig			non sig		

Notes to Table 5.1.5.1:
Height-for-Age and Weight-for-Age are assessed only for children with certain birthdates, use NCHS standards, and refer to a timeline September 1986, or nearest month within three months.
T-Tests have been considered one-tailed.
Only children over two years old at the time line are considered.

Clayveld children born during the rains (when they have highest birthweight) actually grow up to be shorter and lighter than those born during the dry season. However, sandveld and boundary children appear to be less influenced by the season of birth. The clayveld result suggests that irrespective of seasonal changes in birthweight, more significant influences on child growth occur in subsequent seasons. In 5.2 it is established that child growth in clayveld populations is slower during the dry season. The age of twelve and eighteen months is the stage of greatest decline in growth relative to NCHS standards in this population. Therefore clayveld children born during the rains will be in the dry season (the harshest season for them) during the period of greatest vulnerability to failure to thrive. However, it is not clear why the sandveld and boundary population do not show an absolutely opposite pattern to clayveld; after all, in other moist savannahs it is advantageous to be born in the early rains (Billewicz and McGregor, 1981:231); or late dry season just before the rains break (Cantrelle and Leridon, 1971:518). The sandveld/boundary population may show little seasonality due to the effect of the stability of the boundary population, but there is insufficient 'sandveld only' data to examine this.

5.1.6 Conclusions to Section 5.1

This section confirms that underlying ecological seasonal and inter-annual dynamics in food-availability and disease-environment (Chapters Three and Four), are significantly reflected in birthweight variations. Birthweight, however, is little reflected in subsequent growth, though season of birth appears to impose a significant impact on size after the age of two. I now turn to the a detailed examination of the dynamics of growth in these populations in contrasting environments.

5.2. Seasonality in nutritional status and growth: contrasts between ecological zones

Introduction

This section examines whether the contrasting seasonal patterns of 'environmental stress' in sandveld and clayveld described in Chapters Three and Four affect child growth and anthropometric status.

Section 5.2.1 is a literature review that establishes the basic hypotheses of contrasting seasonality of growth to be tested in this section. 5.2.2 then presents data on seasonality of weight-for-age, height-for-age and weight-for-height as a first evaluation. Section 5.2.3 then examines evidence for seasonal changes in growth velocity (weight gain). Next 5.2.4 presents data on anthropometric status of Primary School children. Then 5.2.5 examines data for 1981-5 to see whether seasonal patterns documented for the dry year 1986-7 are similar to those in other years. Finally, Section 5.2.6 reviews the results obtained in 5.2.2, 5.2.3, 5.2.4 and 5.2.5 and concludes on whether there is indeed good evidence for contrasting seasonality in nutritional status between the populations on different soil types.

Sources of Data and Methods of Analysis

There are two sources of data used in the analysis in Sections 5.2 and 5.3. Over two years between July 1986 and July 1988, I measured the weights and heights of the children at bimonthly intervals as described in the Methods Chapter. Secondly, weight/age data for these same children was taken from their 'Road to Health' cards, which all children are supposed to hold. Records on these cards go back to 1981 in a few cases. The 'Road to Health' measures were taken intermittently in the development of each child, and there are too few data at each time interval to overcome inter-child variation. Therefore these data are not very amenable to analysis, except for 'growth velocity' calculations, where weight data points for one child are available within three months of eachother. Additionally, during the peak of the 1982-4 drought many of the measures appear to reflect the recovery of children under supplementary feeding programmes. Comparison of separate weighings taken by myself and clinic nurses in mid-1986 showed no systematic bias, and the weights for each child were very similar. This suggests that clinic data is no less reliable than my own, and can be legitimately treated with my own measures in one analysis.

A 'core-sample' has been used for some of the analysis of my own 1986-7 records. These are the 37 children between two and ten years old for whom there are complete data (5 measures of height and weight, and a definite birth date). This data sub-set is useful as it minimises effects of inter-child variation. A slightly larger 'core sample' can be used where exact birth month is not necessary for the determination of weight-for-height status. This larger sample is used for the growth velocity study. The age/sex composition for these core sample children is given by zone in Table 5.2.1.

Table 5.2.1 Age-sex composition of the core samples from the different zones

	SANDVELD		BOUNDARY		CLAYVELD	
	Boys	Girls	Boys	Girls	Boys	Girls
Ages (months)						
25 to 36	0	1	2	1	1	3
37 to 48	0	1	3	1	0	0
49 to 60	0	0	1	3	1	0
61 to 120	2	2	3	4	2	6
Totals	2	2	9	9	4	9
	(6)		(18)		(13)	

Notes to Table 5.2.1
Age is given as the age at the start of the anthropometric survey [July, 1986]. The small sample sizes mean that distribution by age/sex class is irregular. The purpose of the tabulation is to explore whether there are sample differences that might account for differences in the results, eg. in the sex ratio or by age (young children might be more vulnerable to declines in anthropometric status, for example). Generally speaking the sandveld and clayveld data is closely comparable; equally female biased, with two thirds of the children over five years.

It should be stressed, however, that sample sizes are very small in sandveld and clayveld populations. Boundary population data is slightly different with more young children and equal numbers of males and females. Use of the core-sample remains open to criticism through other researchers deriving hypothesis that test how sample structure could have biased results. Note that in this population there is no sex difference in anthropometric status, or age trend over two years of age.

5.2.1 Review of existing material on growth seasonality in savannah Africa

Introduction

Small, and still unexplained seasonal changes in growth rate occur even where there is apparently adequate food supply, little seasonality in energy expenditure, and low morbidity;[5] but such underlying changes in growth rate can readily be swamped by environmental influences where these are substantial. Seasonality in growth in African children has been researched in detail in several areas, even though in practice most anthropometric research in Africa still ignores the seasonal dimension. Research has established that in many moist savannah zones there is a distinct faltering in growth during the rainy season, the causes of which include seasonal changes in energy expenditure (but less so in children), see below, disease environment (Chapter Six) as well as food supply. In this section I review the literature justifying a nutritional seasonality for the clayveld populations in Mazvihwa that is in contrast to the accepted regime for savannahs. I propose that the wet season growth faltering occurs only in the sandveld population.

Nutritional seasonality data for Zimbabwe

The early field studies and more recent large nutrition surveys in Zimbabwe have all ignored seasonality.[6] Therefore only (conflicting) and anecdotal evidence is available on seasonality in nutritional status for this country. Some workers have noted that food tends to be shortest in the October-January/March period, and therefore assume that the late-dry and rainy season is the period of highest malnutrition (Miller-Cranko and Gelfand, 1958:18; Kizita, 1982:195; Sanders, 1982b:189-90; UNICEF, 1985:42; Bell and Hotchkiss, 1988). Others, impressed by the harshness of the non-agricultural dry season, have cited this as the time of highest malnutrition (Axton, 1977:199; Allart, 1983:58+61; Franklin Donaldson, 1984:199). Baker-

Jones (1954), the Government Nutritionist in the 1940s-1950s, surveyed Medical Officers around the country on the times of year that they thought there were the highest levels of kwashiokor. Harare and Gweru (highveld towns) reported no seasonality; Mutare, Masvingo, Umvuma, reported wet season highs, whilst Kadoma and Mberengwa-Zvishavane-Runde reported higher levels in the dry season. It is unlikely that the reports were made from detailed statistical examination of attendance data, and therefore I will not try to interpret the results, except by saying that considerable variation (and confusion?) seems to have existed.

There are two sources of semi-empirical data on nutritional seasonality in Zimbabwe. From clinic attendance surveys in August 1986 and February 1987 by Dr Luchinger in Chirumhanzu (data through M. Drinkwater, pers. comm. 1988) recorded no difference in level of malnutrition. (In Section 5.3 this result is reinterpreted to suggest that it was the effect of compounding inter-annual variation with seasonal variation.) Secondly Serum protein levels in labourers in Harare declined 'in the hot weather, immediately before the rainy season' (Carr and Gelfand, 1960), suggesting that this might be a time of physiological/nutritional stress.

General patterns of seasonality in nutritional status in African savannahs: a hypothesised contrast between arid and moist savannah systems

Detailed studies by the Medical Research Council-sponsored Dunn Nutrition Unit (Cambridge), and others, in the Gambia have done much to popularise awareness that considerable reduction in growth can occur in the wet season in Africa (eg. Marsden and Marsden, 1965; McGregor *et al.* 1968; Spalding *et al.* 1977). This has been linked to a literature on 'seasonal hunger', through which large sections of communities experience recurring food shortages in the pre-harvest period (Richards, 1939). Whilst seasonal hunger is widespread in savannah-Africa (Lynn, 1937; Annegars, 1973; Ogubu, 1973; Schofield, 1974), its existence has often been uncritically extended to other areas (Miracle, 1961; Annegars, 1973). Although many factors contribute to seasonal hunger, the lack of storability of grain is critical (Nurse, 1975:7,10). Indeed Dugdale and Payne (1987) have constructed a model that demonstrates that it makes sense in energetic terms to go through periods of glut and hunger to minise losses to storage pests and energy expenditure in maintaining body weight; this may be so even at annual losses of 10% of the crop to granary pests especially weevils (contrary to Miracle, 1961:281). It is generally argued that it is the poorest who suffer most from seasonal hunger (eg. Gordon, 1979), but there is actually no data demonstrating this (Longhurst and Payne, 1981:49). The most detailed investigation of this to date, Martin (1985), found no overall reduction in cereal intake amongst the poorest in an agro-pastoralist population in Mali, even when they had run out of their own millet. Some individuals, particularly in one of her two study villages, did reduce intake, however. (See Chapter Four for data on this for this population in Zimbabwe.)

Seasonal hunger tends to be most marked in the moist 'Guinea' savannah systems (Weiner and Wheeler, 1979:222), where harvest is restricted to a brief period, but high humidity and poorly storing crop species lead to a rapid decay. Where there are effective crop storage mechanisms, seasonal hunger is much less marked (Morgan, 1959:62-4; Annegars, 1973). It is in the semi-arid savannah areas that the types of crops (notably millets) are grown that can store well, and conditions are anyway less humid which makes the food-stuffs rot less quickly. Furthermore, higher inter-annual variation in crop yields in this zone make the storage of grain from year to year essential, so that seasonal deficits are less likely to occur. (See Chapter Four, for data for this study: most of the grain eaten over the three years monitored was produced in a single year.) The fact that 'seasonal hunger' is actually less common in the semi-arid savannah zone than is generally believed (because people can compensate with stored over food etc.), helps to interpret food consumption data from Chapter Four which suggest that there is no regular wet season shortfall in this area of Zimbabwe (just as people had informed me).

Research into the 'seasonal hunger' phenomenon has shown that there is a marked cycle in adult body weight in these areas (Fox, 1953; Hunter, 1967; Thomson *et al.* 1966; Nurse, 1968; Rosetta, 1986; Prentice and Prentice, 1988; Davey, n.d.; Kumar, 1988). However, G.A. Wigwe (in Hunter, 1967:184) and Weiner (1980:426-7) have argued that this is just as much a reflection of increased energy expenditure during the agricultural season as it is a function of reduced food intake. Measured energy expenditures of both men and women have been shown to be much higher during the rainy season (Fox, 1953; Bleiberg *et al.* 1980; Brun *et al.* 1981; Lawrence and Whitehead, 1988).[7] In fact, most of the studies of food consumption in areas of seasonal hunger that have been undertaken actually show either that there is no decrease, or even that there is an increase in calorific intake during the period of 'hunger': that is in case studies in Jos Plateau, Nigeria (Collis *et al.* 1962:143); Eastern Kenya (Steenbergen *et al.* 1978); Senegal (Longhurst and Payne, 1981:49); Zaria in Northern Nigeria (Simmons, 1981:76-8); Rimaibe agro-pastoralists of Mali (Hildebrand *et al.* 1985:43; Cameroun/Chad (De Garine and Koppert, 1988:235); and Eastern Zambia (Kumar, 1988:1053-4). It should be noted, however, that marked changes in composition of the diet generally occur at these times, and people often consider that it declines in quality, however well it is maintained in quantity. Nevertheless there are studies that do demonstrate some reduced consumption during the rains, (eg. Rosetta, 1988c for Senegal; and Miller and Rivers, 1972, and possibly Selinus *et al.* 1971, for Ethiopia). Yet despite this central role for energy expenditure, research in equatorial rainforest, where dry season labour is more intense than that during the rains, recorded that weight was still lost during the rainy season (Pagezy, 1982, 1984). Pagezy (1984:13-4) holds that this is because the dry season diet is more nutritious, though it may - of course - reflect disease environment not energy balance at all. Evidence presented for seasonal growth in children in this area (Pagezy and Hauspie, 1985) is generally unconvincing as fluctuations appear essentially erratic.

Care must be taken in the examination of different anthropometric indicators of changing nutritional status in studies of seasonality, as height tends to inherently respond more slowly than weight (Brown *et al.* 1982; Rosetta, 1988b:182-4; Walker and Golden, 1988). Uncertainties remain, furthermore, about the nutritional determinants of height gain in relation to overall calorific and protein intake (Rivers, 1988).

Cooking and appetite rather than food availability *per se* may also lead to seasonal weight changes. During the agricultural season in areas where women do most field work there tends to be a reduction in the frequency and standard of cooking at busy times (Nurse, 1975:8,4 and 1968:148). The lack of preferred relish items may have a negative psychological effect on the enthusiasm to eat (Pagezy, 1984:14); Miller and Rivers (1972) argued that seasonal falls in energy intake in Ethiopia reflected declines in palatability of the diet due to changes in the specific food type availabilities. According to Billewicz and McGregor (1982:317) even the 'high temperature and humidity [during the rainy season] which make life uncomfortable . . . may affect appetite'; see also Thomson *et al.* 1966:731;

Tomkins *et al.* 1986:542. Declines in health during the wet season is probably another major factor for declining nutritional status (Hassan *et al.* 1985; Billewicz and McGregor, 1982:310,317). A particularly convincing demonstration of this is a study of urban children in Bakau, Gambia (Tomkins *et al.* 1986). These children do not experience any seasonal food shortage or heavy labour demands, but yet still show the wet season weight velocity reductions typified by the rural studies at Keneba (see above). These probably reflects their continued vulnerability to temperature and hygiene related morbidity and loss in appetite (Tomkins *et al.* 1986:541-2), see Chapter Six for an exploration of this relationship between nutritional status and morbidity.

Wet season declines in child nutritional status have been recorded in many African moist savannah areas in addition to the long-standing Gambian work described above. Case studies include: Senegal (Rosetta, 1988b); Uganda (Poskitt, 1972); Tanzania (Goetz, 1981:185); Sekhukumiland in South Africa (Waldemann, 1973); Zambia (Ogle, 1989:9); central Northern Nigeria (Tomkins, 1981:178); parts of Ethiopia (Berhan, 1982); to a certain extent in Lesotho, though there also may be a dry season low in nutritional status (Huss-Ashmore, 1982); and possibly in Southern Sudan (Wilson, 1985a:69). It is well studied in the Indian sub-continent (eg. Brown *et al.* 1982).

Only recently has research on nutritional seasonality has been conducted in the semi-arid savannah regions. This suggests that in this zone the seasonal pattern of growth is the reverse of that in moist savannahs, and that the dry season becomes the time of weight loss and growth faltering. Loutan (1985:213-5) found adult Wodaabe pastoralists in an arid area experiencing a mean of just 200-300mm rainfall showed the highest body weights in the post-harvest season, and the lowest in the hot dry period. A study of children in this population found that weight was dramatically lost during the hot part of the dry season (Loutan and Lamotte, 1984); the proportion of children below 80% of weight-for-height standards increased from around 7% to 17% at this time (1984:946). Centers for Disease Control nutrition surveys in two hot dry seasons and the intervening post-harvest seasons in Mali and Mauritania found the highest malnutrition levels in the hot dry season, which they propose as "normal" for the Sahel (Hogan *et al.*, 1977:119, 121, 124). In a village study, Hildebrand (1985:268-74) also found children gaining weight in the rains and post harvest season and losing it through the dry season in agro-pastoral populations in Mali; the most dramatic loss occurred in December/January to March/April of the hot dry season, and with some rains (50mm by the end of June), growth velocity increased enormously for the March/April to June/July interval (Hildebrand *et al.* 1985:88). Adults in the Malian agro-pastoralist population studied by Hildebrand (1985:265-8; Hildebrand *et al.* 1985:75-8) showed some weight loss during the hot dry season, and a period of gains in the rains, harvest and cold dry season, except for male agriculturalists, who lost weight during the rains. Relative seasonal weight loss patterns are therefore mainly a function of energy expenditure and vary with the extent to which individuals are involved in (wet season) agricultural labour and (dry season) water aquisition, with interesting variations between the sexes and ethnic groups.

The growth of children in semi-arid Botswana also followed a pattern of wet and post-harvest season gains, and dry season losses, Mason *et al.* 1987:173 (but only in non-drought years). Galvin (1988) describes how Turkana pastoralist diet is better in the wet season, and notes how this leads to upswings in adult body weights with a several month timelag, pointing out that this can lead to upswings during times of apparent stress. Corkill (1954) also records the poverty of diet in the semi-arid pastoralist north Sudan, and a number of dry seasonal nutritional disorders that resulted from this (1954:262). Somali pastoralists of the semi-desert may also have highest nutritional status at the end of the rains (Burton/Waterfield, 1856/1966:19; Lewis, 1961:43: quoted in Seaman *et al.* 1978:37).

However, two studies from the Sahel do not entirely corroborate the general finding of dry season nutritional stress in semi-arid environments, suggesting that in agro-pastoral populations in these regions there can be both a hot dry and wet season decline in nutritional status. In the Niger Delta in Mali, adult pastoralist Tamasheq in this area do indeed show declining weight in the hot dry season as predicted (Wagenaar-Brouwer, 1985:236-8), but in contrast, agro-pastoralist Fulani and Rimaibe show reducing nutritional status in the rains amongst both adults and children, though there is also a decline in the hot dry season after a harvest-cold dry season peak (Wagenaar-Brouwer, 1985:240-5). This presumably reflects a combination of the nutritionally ameliorating effects of the Niger floodplain, and the fact that some populations are intensely agricultural. Similar wet and hot dry season times of nutritional stress are suggested in a study of the Senegal-Ferlo, but there were differences between age-groups and types of anthropometric measurement, and with the dry season at the start, and at the end, of the year long study (Benefice *et al.* 1984). (Disease environment effects may also be involved in these situations.)

It is important to note that seasonal patterns in savannahs with high inter-annual variation in rainfall will also be highly variable (De Garine and Koppert, 1988:225,228; Mason *et al.* 1987:173). Examination of seasonality contrasts between wet and dry years in Mazvihwa is made in Section 5.2.5.

Seasonality in Vitamin Deficiencies

No attempt was made in my own study to watch for seasonal changes in vitamin deficiencies. This was both due to my lack of technical ability and awareness at the time, and because they did not appear to be an issue. However, material I will now review suggests that seasonal vitamin deficiencies are a common feature of semi-arid savannah systems. This fact is worth considering when appraising and concluding from my examination of seasonality in protein-energy malnutrition.

Mayer (1963:87) has commented on how the extreme seasonal variations in diet inevitable in the semi-arid savannahs will tend to expose people to seasonal vitamin deficiencies. Dry season peaks in avitaminosis A are marked in the Sahel, largely due to reduced milk consumption (Hildebrand *et al.* 1985:58-9), and it is notable that the extent of the problem in the dry season is greater in the arid areas (Burkina Faso and South Mali) than the moister savannah areas (Casamance, Senegal), according to the study by Francois *et al.* (1980), and similar conclusions have been drawn by Jelliffe (1952:27) and Tomkins (1981:178-9). A global survey of xerophthalmia (a consequence of vitamin A deficiency) by Oomen *et al.* also found that it was more common in the drier areas of Tanzania (the Gogo of Mvumi) than moister areas (Sukuma of Mwanza) (1964:299-300), and has been recorded as a problem in the arid areas of Northern Nigeria and Botswana (1964:300) and in the Gezira area of Northern Sudan (1964:297-8). There is conflicting evidence about the extent of vitamin A deficiency in Zimbabwe (UNICEF, 1985:3), and no thorough research into the dynamics of its seasonality. But vitamin C deficiency has been said to occur (or have once occurred) predominantly during the dry season in Zimbabwe (Nutrition Council, 1948:2).

Pellagra (niacin deficiency) is an issue in those parts of Zimbabwe depending more exclusively upon maize (Nutrition Council, 1948), especially for individuals who do not consume local beer, which may also be important for other micro-nutrients (Baker-Jones, 1956:67). Little is known about other micro-nutrient deficiencies in Zimbabwe, or elsewhere in savannah Africa, but goitre is found in areas of the country with iodine deficient soils (for example, Chimanda, Chikwaka and Omay), UNICEF (1985:44), and can be exacerbated by *Brassica* consumption (J. McGregor, pers. comm. 1989; Baker Jones, 1956:67). There has been no investigation of micro-nutrient seasonality in Zimbabwe.

5.2.2 Seasonality in anthropometric status in 1986-7: sandveld and clayveld contrasted

This sections examines evidence for seasonally changing anthropometric status in the core sample (see Section 5.2 Introduction for analysis method).

Seasonal changes in 'weight for height' 1986-7

'Weight for height' analysis (Table 5.2.2.1) suggests that there are differences in seasonality between the populations. During the dry season sandveld status is better than that on clayveld; but sandveld status declines markedly in the rains. In contrast clayveld status declines during the dry season, but improves (slightly) with the rains. The boundary population that utilises both sandveld and clayveld shows a pattern intermediate between sandveld and clayveld, as predicted.

Table 5.2.2.1 Weight-for-Height; two to ten year olds, sexes pooled, 1986-7

		Cold Dry				Hot Dry		Rains		Harvest	
	N.	July		Sept		Nov		Jan		March	
		mean	σn-1	mean	σn-1	mean	σn-1	mean	σn-1	mean	σn-1
Sandveld	6	101.0	11.81	97.5	7.34	101.6	5.95	94.8	5.00	93.0	5.81
Boundary	24	99.0	8.36	99.0	9.20	97.6	7.54	96.5	7.74	98.8	9.72
Clayveld	17	98.3	6.93	95.0	6.72	92.9	6.37	94.2	5.73	92.1	6.83

Notes to Table 5.2.2.1
Sandveld weight-for-height is better than clayveld during the dry season. In November $t=2.45$, 21df, $p<0.025$. The decline in sandveld status between the hot dry season (Nov), and the rains (Jan) is statistically significant; $t=1.95$, 10df, $p<0.05$

Seasonal changes in Weight-for-Age, 1986-7

Table 5.2.2.3 presents data that suggest that 'weight for age' status may also change in a different manner between ecological zones, as predicted by the theoretical discussion of 5.2.1. Stress appears concentrated in the dry season on clayveld and the rainy season on sandveld, whilst the population on the boundary between the zones experiences an ameliorated regime.

Table 5.2.2.3 Weight-for-Age status, 1986-7

Under two year olds, sexes pooled.

	N.	Cold Dry July mean	Cold Dry July σn-1	Hot Dry Sept mean	Hot Dry Sept σn-1	Hot Dry Nov mean	Hot Dry Nov σn-1	Rains Jan mean	Rains Jan σn-1	Harvest March mean	Harvest March σn-1
Boundary	6	76.6	8.13	77.1	4.94	73.3	5.07	75.8	5.59	79.1	6.94
Clayveld	4	92.2	11.28	84.8	7.80	82.3	7.69	85.2	10.57	87.2	9.49

Two to ten year olds, sexes pooled.

	N.	Cold Dry July mean	Cold Dry July σn-1	Hot Dry Sept mean	Hot Dry Sept σn-1	Hot Dry Nov mean	Hot Dry Nov σn-1	Rains Jan mean	Rains Jan σn-1	Harvest March mean	Harvest March σn-1
Sandveld	6	83.1	2.88	87.4	6.13	95.1	12.90	82.1	6.37	81.9	6.54
Boundary	18	85.5	8.22	85.0	7.80	84.4	9.25	83.4	8.43	86.1	9.99
Clayveld	13	87.4	9.72	84.6	9.41	83.1	8.73	83.5	7.08	83.7	9.14

Notes for Table 5.2.2.3
There are no sandveld core sample data for under two-year-olds. Mean age for boundary and clayveld under two year olds at July 1986 was 15.2 and 16.3 months respectively.

Sandveld declines in weight-for-age at the onset of the rains (Nov-Jan) are statistically significant; $t=2.01$, 10df, $p<0.05$

Other changes and contrasts are not statistically significant.

Clayveld and sandveld samples in Table 5.2.2.3 suggest contrasting patterns of weight-for-age status, but the differences are generally not statistically significant. During the dry season sandveld status rises whilst clayveld status is falling. With the onset of the rains sandveld status declines markedly (statistically significantly so), whilst clayveld status improves a little. Boundary populations show a pattern of little change. Even clayveld children under two years of age appear to decline in weight-for-age in the dry season and improve in the rains.

Seasonal changes in Height-for-Age status, 1986-7

Seasonal changes in 'height-for-age' were investigated (Table 5.2.2.4) to determine whether they manifested contrasting patterns between the ecological zones. Height-for-age status changes much less markedly through the season than do those assessments including weight. Furthermore, a similar seasonal regime was found was found in all three zones. Lowest height-for-age status was shown in the hot dry season (either September or November), and greatest increases during and after the rains. Periodicity in growth in height may have underlying determinants more fundamental than seasonal food availability and morbidity (see Section 5.2.1 for literature review).

Table 5.2.2.4 Height-for-Age Status: two to ten year olds, sexes pooled, 1986-7

	N.	Cold Dry July mean	σn-1	Sept mean	σn-1	Hot Dry Nov mean	σn-1	Rains Jan mean	σn-1	Harvest March mean	σn-1
Sandveld	6	90.0	2.88	90.4	2.17	89.8	2.59	92.1	2.66	92.9	1.10
Boundary	18	93.1	4.08	92.9	3.97	93.0	3.92	93.3	3.96	94.1	3.92
Clayveld	13	94.1	3.44	94.7	3.68	94.8	3.41	95.0	3.90	95.8	3.55

Notes for Table 5.2.2.4
Data for children under two are not included as their lengths were not recorded sufficiently accurately.

The declines in Height-for-Age status reflect the fact that growth in this time interval were less than the mean increment for NCHS standard populations, not that they lost height.

5.2.3 Seasonal growth velocity (weight gain) in children aged one to seven: sandveld and clayveld contrasts

This section considers weight gain (growth velocity) in children aged one to seven years of age. Children in this age group gain 2.2kg/year to maintain NCHS standards, independent of age and sex. Weight changes highlight seasonal contrasts; in part this is because they usefully avoid high variations in existing child anthropometric status at the start of the assessment. Unlike weight-for-height, direct weight-change assessment also ignores underlying periodicity in growth in height.

Growth velocity in the core sample, 1986-7

The figures were calculated directly from the differences between weights after each two month measurement interval.

In the sandveld children most of the weight gain over the nine months was achieved between Sept and November in the hot dry season, whilst weight was actually lost during the early rains period (Table 5.2.3.1). In the clayveld children, however, the weight gain for the nine months occurred mainly in the rainy season, with weight gain then continuing more slowly, before being lost or just maintained during the cold and hot dry seasons. Most ways of contrasting sandveld and clayveld seasonal patterns are statistically significant in this sample.

The children in the boundary population had a more even pattern of growth than either the clayveld or sandveld population. On average they did not actually lose weight at any period of the year. Nevertheless, a considerable (and statistically significant) portion of the weight gain occurred in the post harvest period.

Table 5.2.3.1 Weight gains for core sample children aged one to seven years, sexes pooled, 1986-7

	N.	Cold Dry July - Sept mean (kg)	σn-1	Hot Dry Sept - Nov mean (kg)	σn-1	Rains Nov - Jan mean (kg)	σn-1	Harvest Jan - Mar mean (kg)	σn-1
Sandveld	6	0.15	0.12	0.65	0.34	-0.17	0.29	0.17	0.30
Boundary	29	0.24	0.46	0.05	0.49	0.29	0.53	0.96	0.99
Clayveld	18	-0.06	0.58	0.02	0.76	0.63	0.76	0.32	0.82

Notes to Table 5.2.3.1
The figures were calculated directly from the differences between weights between each two month interval, and can be converted into an annual growth velocity through multiplication by six. The (NCHS standard) rate of weight gain per year of both male and female children from twelve months to seven years is approximately constant around 2.2kg/year. Above and below this there are considerable differences in expected weight gain so these other age categories have been excluded from this analysis.

Statistical significance of differences

Sandveld contrasted with Clayveld
July-Sept 1986; sandveld v. clayveld weight gain; t= 0.85, 22df, p<0.25 n.s.
Sept-Nov 1986; sandveld v. clayveld weight gain; t= 1.91, 22df, p<0.05
Nov 1986-Jan 1987; sandveld v. clayveld weight gain; t= 2.42, 22df, p<0.025
Jan-Mar 1987; sandveld v clayveld weight gain; t= 0.42, 22df, p<0.25 n.s.

Dry Season versus Wet Season
July-Sept 1986 versus Nov-Jan 1986-7 clayveld; t= 2.97, 34df, p<0.005
Sept-Nov 1986 versus Nov-Jan 1986-7 sandveld; t= 4.08, 10df, p<0.0025

The full annual picture of growth velocity in weight in 1986-7 is not presented here because of lack of measures between March and the following July. But the sandveld population did indeed grow better in the early dry season of 1987, as they had done in the previous late dry season; this is known because these children (virtually) maintained their weight growth velocity over the year 1987-88, as is shown in Section 5.3 on interannual variation. Likewise clayveld children must have continued to lose weight in the next dry season as expected, as by wet season 1988 they were on average lighter for their age than in 1987; see 5.3 below.

Growth velocity of all children aged one to seven years in 1986-7

This section examines growth velocity (weight gain) of all children in the 1986-7 study sample, so as to test the validity of the core-sample results presented above.

The nature of the data and analysis
The justification for analysis of a small 'core sample' of children (above) was that by minimising variability between children, seasonal patterns would be clearer. In the following analysis data is used for all children (between 1 and 7 years of age) measured in 1986-7, ie. to try to control for high variation between children through large sample size. Between the ages of one and seven years of age both male and female standard weight gain per year basically remains constant at around 2.2kg/annum, though growth will tend to be uneven within this period. One, two, or three months intervals are considered and converted into a velocity of weight gain in kg/annum. This velocity is assigned to each of the months involved.

A maximum interval of three months was chosen as a compromise between creating a sufficiently large sample size, and maintaining a capacity to register short term changes in weight that are a feature of seasonal stresses. In practise during 1986-7 nearly all intervals were two months because of the particular weighing regime for the sample. Intervals of one and three months were a result of their being weighed as school children or for some other purpose. In Section 5.2.5 on interannual variation weight increment data for intervals of one, two and three monthly intervals are presented for clayveld children in 1981-5. This data shows that there are not systematic differences between the velocities of increments of different lengths.

Table 5.2.3.2 Growth velocities of one to seven year olds in 1986-7
Annual weight gain velocities by months

		Sandveld			Clayveld			t-test
		n	mean vel.	σn-1	n	mean vel.	σn-1	p<
Jul	Cold	0			15	-0.15	3.28	-
Aug	dry	8	1.20	3.59	29	-0.59	5.10	0.25
Sep	Hot	8	0.25	1.36	29	2.18	3.56	@
Oct	dry	8	3.03	2.23	28	1.37	2.71	0.1
Nov		8	3.03	2.23	28	1.02	5.83	0.25
Dec	Rains	8	-0.45	2.07	32	4.01	4.85	0.01
Jan		8	-0.45	2.07	33	3.94	3.97	0.005
Feb		5	0.36	2.31	33	4.40	5.60	0.1
Mar	Harvest	5	0.36	2.31	18	3.77	5.30	0.1

Annual Weight Gain Velocities by Season

	Sandveld			Clayveld			t-test
	n	mean vel.	σn-1	n	mean vel.	σn-1	p<
Dry Season	32	1.88	2.65	129	0.86	4.43	=0.1
Rains	26	-0.14	2.07	116	4.06	4.56	0.0005
t-test dry v wet		p<0.0025			p<0.0005		

Notes to Table 5.2.3.2
Velocities are presented as kg/annum, according to the rates in weight change in a given month.
Note that the sandveld sample is very small

@; the difference in this one particular comparison of the eight in Table 5.2.3.2 is the opposite to that predicted, with p<0.1

The data in Table 5.2.3.2 confirm the hypothesis of contrasting growth seasonality between the two ecological zones. Sandveld children grow faster during the dry season than in the wet season, and clayveld children the reverse. Furthermore, clayveld weight gain is greater than that of sandveld during the rains, but weight-gain in sandveld is greater than clayveld during the dry season. These results support those found in the core sample (see Table 5.2.3.1)

5.2.4 Changes in anthropometric status in Primary School Children, 1986-7

The anthropometric status of primary school children provide a further test of the predicted differences in seasonal stress between the ecological zones.

Nature of the data and analysis
Heights and weights were taken three times at three primary schools in the area (July 1986, October 1986 and January 1987). Two of these schools are on the clayveld: Gudo and Mototi, though some children from the boundary population do attend Mototi. The third school, Gwenombe Dip, contains children from both the boundary population and the sandveld proper. There are no boarding students. Analysis has been carried out using the data from only those children for whom all three measures were available. No accurate birth dates are possible as falsified certificates and class lists are the norm in schools. Therefore only weight-for-height data is used for this analysis.

Table 5.2.4.1 Primary School Children 1986-7: Seasonal changes in Weight-for-Height status

	Clayveld Gudo % Weight for Height			Boundary + Clayveld Mototi % Weight for Height			Boundary + Sandveld Gwenombe Dip % Weight for Height		
	<90	91-100	>101	<90	91-100	>101	<90	91-100	>101
July	11	28	13	18	54	29	24	42	15
October	21	26	5	27	56	18	29	41	11
January	18	26	8	27	57	17	23	44	14

Notes to Table 5.2.4.1
This table contains data for only children for whom there are measures at all three weighings. The numbers correspond to the number of individual children who fall into that category of percentage weight-for-height. The sample comprises children who were in grades 1 and 2 in July 1986.These are mainly 7 to 10 year olds. The older children further up in the school were not included to avoid problems of the adolescent growth spurt.

The distribution of weight-for-height classes by season in the school with a boundary and sandveld attendance, was less deviant from random than that with the clayveld schools. With the clayveld schools pooled the distribution is significantly non-random (χ^2= 17.3, 4df, p<0.01). This suggests greater seasonality on clayveld (hot dry season loss).

All three schools in the three zones presented declining weight-for-height status from the early to the late dry season, but this was most marked in the clayveld schools, as predicted. Clayveld schools showed a changing seasonal distribution of weight-for-height categories that was statistically different from a null hypothesis of randomness. In the rainy season there was a slight improvement in one of the clayveld schools and at the boundary and sandveld school. I expected the clayveld to improve more than sandveld with the rains, as has been shown in the under ten year olds (see Sections 5.2.2 and 5.2.3). Further research seems appropriate on whether seasonal patterns seen in under ten year olds are replicated in older children and adults, which might relate particularly to energy expenditure, whereas under fives are more influenced by diet and morbidity (cf. McGregor, 1976:183).

Table 5.2.4.2. Relative changes in weight in primary school children

	Dry Season July - October mean increment		Rainy Season October - Jan mean increment		Overall Trajectory July - January	
	+ve	-ve	+ve	-ve	u-shaped	n-shaped
Sand+boundary[1]	10	0	10	0	4	6
Boundary+clay[2]	11	1	10	2	10	2
Clayveld[3]	4	8	10	2	9	3

Notes to Table 5.2.4.2
1 = Gwen'ombe Dip school
2 = Mototi school
3 = Gudo school

Each unit in the table is a 'class' (group of pupils assigned to a teacher) within the school, divided into two groups by sex. The classes are made up only of individuals measured at all three intervals. Each class contains between 10 and 30 individuals. The classes comprise the grades 1 to 6 within the primary schools. (The grade 6s became grade 7s in the third, January, weighing). They range in age from six to eight years to around twelve to sixteen years.

Positive mean increments are those where on average the individuals in this age-sex class gained in mass during that period, and negative mean increments refer to an absolute loss in weight, on average, in that age-sex class.

The 'overall trajectory' refers to the pattern of growth between the first and third weighing. The trajectory (curve) of the graph was described as either u- or n-shaped depending on whether the middle measure (October; the hot dry season) was above or below the intersect between the first and third measure. This was taken as an assessment of the relative importance of the decline seen in weight-for-height in the hot dry season.

This difference is not amenable to statistical testing as the sample is too small to use the χ^2, as some 'expected' values fall below 5.

The data in Table 5.2.4.2 suggest that dry season weight loss in 1986 was a more significant component of weight change in the clayveld schools than in those of sandveld and boundary. This is as predicted as clayveld children are thus shown to experience greater dry season stress.

5.2.5 Seasonal weight gain velocity in years of high and low rainfall

This section examines the seasonal pattern of weight gain in additional years to the single season (1986-7) that was studied in detail, see Sections 5.2.2, 5.2.3 and 5.2.4.

1986-7 was a dry year and it is therefore investigated whether the same seasonal pattern of weight gain is shown in each of the ecological zones in three other dry years (1982-4). In addition, the little data available for wet years, and only for clayveld, examines whether the high rainfall years show patterns similar to those of dry years.

Source of Data and Method of Analysis
Weight gain velocity for the period 1981-5 was derived from childrens' individual Road to Health Cards. These weighings were made by clinic staff in their regular Mother and Child clinics, when children come to the clinic sick, and as part of growth monitoring and supplementary feeding during drought years. Velocity was calculated from cases where there were two weighings within three months apart, and converted into Kg lost or gained per year. 12kg/year and -9kg/year were considered the maximum weight change velocities acceptable over the one to two month periods. 12 of the 203 individual velocity measures exceeded these velocities, and so were adjusted down to these figures. Analysis showed that there was no statistical difference between weight velocities as assessed on a one, two or three month interval. Analysis and presentation of data is otherwise identical to the assessment of weight gain velocity in Section 5.2.3.

Table 5.2.5.1 Seasonal Pattern of Weight Gain During Wet and Dry Years, One to Seven Year Olds (KG/Year)

	DRY YEARS						DRY YEARS						WET YEARS		
	Sandveld 1982-4			Sandveld 1986-7			Clayveld 1982-4			Clayveld 1986-7			Clayveld 1981+5		
	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}
Season															
Dry	44	2.52	4.32	32	1.88	2.65	67	2.84	5.38	129	0.86	4.43	19	2.26	3.19
Rains	14	0.56	3.97	26	-0.14	2.07	6	7.00	5.90	116	4.06	4.56	18	1.69	5.54
t-test p< dry v rains	t=1.48			0.0025			t=1.77			0.0005			non-sig		

Notes to Table 5.2.5.1
Data for 1986-7 is derived from Table 5.2.3.2.

The dry season refers to July-November inclusive and the wet season December-February in 1981+5 and 1986-7. In 1982-4 the dry season refers to July-December and the wet season January-February. This was because in 1982-4, unlike 1986-7, the rains started very late. At neighbouring Hokonui Ranch there was an average of only 11mm of rain in December in these three years; at Zvishavane, the district capital, there was an average of 50mm, still negligible.

In wet years (1981+5) there is insufficient data for rainy season weight gain velocities to be meaningfully calculated in sandveld.

In clayveld, overall weight gain appears greater than the 2.2Kg/Year expected for children aged one to seven years of age. This may partly reflect biases introduced by the inclusion of children receiving some supplementary feeding between the weighings.

Table 5.2.5.1 shows that dry year seasonal patterns appear fairly constant, as data for the years 1982, 1983 and 1984 show the same pattern as that from 1986-7. Sandveld children show a reduction in growth velocity during the rainy season, whilst in contrast clayveld children show higher weight gain at that time.

During the wet years of 1981+5 clayveld seasonal growth rates appear to be different from that in dry years. Rainy season weight gain velocity is depressed relative to the dry season. However, the difference is non-significant. Therefore it remains uncertain as to whether there is a reduced (or even reversed) pattern of seasonal weight gain in high rainfall years in clayveld. It should be noted that the wet years in the 1980s have been isolated wet years following droughts, as this is a 'dry-cycle' decade (Chapter Three, Section 3.1). Therefore the rainy season in each case is one following several years of deprivation in drought. It may be that seasonal patterns in series of wet years such as those occurring in the 'wet-cycle' are different again. There is currently insufficient data for sandveld in Mototi to examine for any effects for wet years in this zone.

5.2.6 Conclusions to Section 5.2

Section 5.2 first establishes that ecological contrasts between clayveld and sandveld (effecting seasonality in food supplies and disease environments) can indeed be expected to lead to contrasting patterns of growth in the two environments. Seasonal patterns in anthropometric status in a core sample of under ten year olds in 1986-7 do show the expected contrasting pattern, but the statistical validity is rather weak. However, patterns of weight gain velocity in the core and larger sample demonstrate clear and statistically significant seasonal contrasts between zones in 1986-7, replicated in data for 1982-4. On sandveld, weight gain is concentrated in the dry season, whilst on clayveld most increase in weight occurs during the rains. It is noteworthy in this regard that a major study of the capacity of anthropometric variables to detect short term (seasonal) changes in nutritional status (Bairiagi, 1987), found that weight velocity was a much more powerful tool than weight-for-age, height-for-age or weight-for-height. According to growth monitoring at schools, children over ten years old also show greater dry season vulnerability to growth faltering in clayveld. This difference in seasonal patterns in the timing of nutritional stress may be generally reflected in savannah environments with different rainfall and soil-determined dynamics. This is in contrast to the 'classical' view that all populations experience wet season declines.

5.3 Inter-Annual Variation in Anthropometric Status and Growth Contrasts Between Ecological Zones

Introduction

Since the Sahel, Karamoja and Ethiopian famines of the 1970s there has been considerable concern with the 'drought vulnerability' of the nutritional status of the populations of semi-arid savannahs in Africa. Much useful literature has focused on the socio-economic factors rendering populations (and population sub-sectors) differentially vulnerable to drought through time. Research has also been undertaken on agricultural strategies to cope with rainfall variability, and on the supposed ecological trend to desertification that is driving famine vulnerability. Yet there has not been any research on basic ecological relationships between rainfall and food production, and how this is linked to child nutrition, a gap which this chapter will try to address. I have shown in Chapters Three and Four that sandveld and clayveld environments show fundamentally different food productivity and disease environment responses to the same inter-annual rainfall variation. I now test whether these are reflected in contrasting patterns of growth and nutritional status.

Section 5.3.1 reviews existing material on inter-annual variation in anthropometric status, to establish the hypothesis that droughts should lead to declining status only in clayveld and not sandveld. In Section 5.3.2 data on changing nutritional status over a drought period in Zimbabwe test whether there are contrasts between ecological zones, wherby clayveld children are more vulnerable to years of low rainfall. Next, Section 5.3.3 examines growth rates after the harvest that broke the drought to compare recovery between populations of the different ecological zones. Section 5.3.4 concludes from this evidence the extent to which ecological dynamics do shape inter-annual variations in nutritional status.

5.3.1 Review of existing evidence on inter-annual variation in nutritional status in African savannahs

Introduction

No study in an African savannah population to date has monitored cohorts of children over several years of different rainfall and/or food supply, measured this difference, and then analysed the effect of that variability on nutritional status. However, there are two types of data available that suggest that rainfall levels, and assumed changes in food supply and possibly disease environment can affect nutritional status. The first are longtitudinal or sequential cross-sectional studies, and the second are anthropometric measures taken during times of actual drought/famine, some of which can be compared with data for approximately the same population during a more favourable period.

Comparative Data on Growth in Wet and Dry Years: Literature Survey

Several studies, mostly in semi-arid systems where crop production is more vulnerable to rainfall, have indicated higher malnutrition following dry years. In her study of wet season weight loss in Serere, Rosetta found somewhat greater weight loss in the rainy season following a relative crop failure than after a second year with a good harvest (1986:243 and 1988:187). (However, this could well have been due to higher rainfall in this second year, leading to worse morbidity and higher agricultural work levels.) Van Ginneken and Kok (1984:341) in a several year study in semi-arid Eastern Kenya comment that anthropometric status was lower in a dry year, but do not report the magnitude of this nor relate it to levels of agricultural production and income. Cross-sectional surveys between 1977-82 in Kenya, also associated a trend in increasing malnutrition in Eastern Province to drought, though a similar trend in Western Province is attributed to a decline in available agricultural land (Test *et al.* 1985). In a study of the number of cases of malnutrition reported at rural clinics in relation to crop and livestock production estimates in the period 1979 to 1983, Mason *et al.* (1987) report for semi-arid Botswana that drought-related agricultural production data can predict rises in malnutrition fairly effectively. They propose that agricultural productivity indicators in countries with economies like Botswana can be used to make appropriate relief interventions. But they admit that the causal basis of the relationship seen at aggregate level remains unknown (Mason *et al.*, 1987:183). Medical workers after the Sahel drought observed that even the richest and most over-weight Tuareg women had become slim during the period of dearth, though they did remain plumper than poorer women (Epelboin and Epelboin, 1976:251-2). They add, however, that they are unsure of whether this led to medical benefits or costs to the women involved (Epelboin and Epelboin, 1976:252).

Although there is a great paucity of data for moist savannah areas for inter-annual variations in growth, partly because droughts are not seen to be a 'problem' in these areas, there is an indication that growth may be better in the dry years. In the moist savannah area studied in the Gambia, the longtitudinal data available has apparently has not been analysed to explore whether there is any relationship between the level of rainfall and growth. However, greater than usual growth faltering in one year was believed linked to particularly high morbidity consequent on high rainfall (McGregor *et al.* 1970:57). (See Chapter Six for discussion of the effect that high and low rainfall levels can have on morbidity.)

One study in Zimbabwe (Chiwundura in Midlands Province) compared anthropometric assessment in schools in adjacent villages during May 1973 and August 1974. A fall in the percentage of weight-for-height children below 80% (of Boston standards?), from 36.6 to 10% occurred during this time interval (Stewart and Ellis, 1975). Whilst part of this change may reflect typical sandveld seasonality (Section 5.2), it is reasonable to conclude, with the authors, that this was due to an 'acute shortage of food arising from a recent severe drought' which had elevated the levels of malnutrition in 1973 (Stewart and Ellis, 1975:48). This suggests that even sandveld can sometimes be affected by very severe droughts (1972-3 is one of the worst on record). Two other studies in Middleveld sandveld in Zimbabwe suggest that in most drought years there is no effect on nutritional status. Theisen (1978:170-1), also working in Chiwundura, compared measures for wet and dry years, and recorded little difference. Data from Chirumhanzu, collected by the Medical Officer, Dr Luchinger (data from M.J. Drinkwater, pers. comm., 1988), compared the proportion of children below the third percentile of weight-for-age (adapted Boston scale) in August 1986 and February 1987 (over a failed rainy season). Since February is mid-rains, the seasonal effect (Section 5.2) would lead to a drop in nutritional status under 'typical' sandveld conditions. Yet Dr Luchinger found no change in nutritional status and so concluded: 'There is no seasonal difference and the problem of underweight cannot be reduced to the problem of drought related food availability'. However, a more plausible interpretation is that the lack of rain had actually raised nutritional status during February 1987, counteracting the usual seasonal effect. This example draws attention to the errors in interpretation that can occur without consideration of how changes reflect both seasonal and inter-annual dynamics.

In addition to rainfall there are, of course, many other factors causing inter-annual variation in nutritional status. An interesting example is reported for part of the Mandara Mountains of West Africa, where there is a system of alternating the planting of sorghum and millet, year by year on a society-wide basis. Since sorghum yields are considerably higher, and the secondary crops cultivated to supplement the millet are rarely sufficient, there tends to be higher nutritional status following the sorghum-planting years (Burnham, 1980:161).

The conclusion from these studies is that in the semi-arid areas drought can lead to declines in nutritional status in the subsequent year. In contrast drought in the moist savannah may have an immediate positive effect on growth through improving the disease-environment, and drought tends to have little effect upon subsequent growth as it does not lead to such great depression in agricultural production and other food supplies.

Nutritional assessment during drought and famine: comparative data

Weight-for-height is currently the anthropometric indicator of choice for 'famine' assessment, since it is said to indicate 'wasting' (weight loss under immediate, short term nutritional stress), rather than the 'stunting' consequent on long term deprivation that is thought to be picked up by weight-for-age or height-for-age. However, as Rivers (1988:92-9) has so convincingly argued, weight-for-height is not independent of long term nutritional status and does not necessarily reflect immediate weight loss. Comparisons between areas and famines also appear problematic to me. Proportions of populations with anthropometric status below 80% weight-for-height amongst populations from the Horn of Africa and desert pastoralists of the Sahel seem generally much higher than those of Nilote and Bantu extraction further south (see Table 5.3.1.1), raising the spectre of habitual nutrition levels, physiological adaptation, and even genetic differences. (As yet there is little satisfactory data for well nourished populations in the Horn and desert-side of the Sahel, unlike that for other parts of Africa.) Furthermore, Rivers (1988) has shown - and this will be further discussed in Chapter Seven - that the relationship between nutritional status and economic and mortality processes in famines are decidedly unclear (see also Seaman *et al.* 1978; De Waal, 1989b). Indeed given the focus on weight-for-height it is disturbing that recent empirical research on the Bangladesh famine of 1974-5 has found the weight-for-height was actually less sensitive than either weight-for-age or height-for-age (Bairagi *et al.* 1985; Bairagi, 1987).

Several studies have shown that local agro-ecological factors affect vulnerability of food supplies to drought and hence anthropometric measures during shortfall. Particularly significant is access to natural or irrigated wetland, which can maintain productivity during drought. It has been shown in Chapter Three that dambo wetlands play this role in the sandveld environment in Zimbabwe, and are thus a major factor contributing to the stability of productivity in this ecological zone. In the Western Sudan (Shepherd, 1988:29), in Southern Malawi (Vaughan 1985:182-3), and in Mozambique (D'Souza, 1988:32) access to such micro-irrigated sites was found correlated with greater resilience of nutritional status at household and/or community-level during drought. (Note also the suppositions of Korte (1973:271-2) that access to irrigated land in the dry area of Mwea [Kenya] protected people from drought.) Not surprisingly, it is destitute migrants, separated from their land entirely, who tend to suffer the most (eg. Seaman *et al.* 1973:777).

Table 5.3.1.1 presents most of the published data available on nutritional status during the major African drought-related famines of the last two decades.[6] The data are profoundly disappointing. Generally they present one-off surveys without indication of whether nutritional status was rising or falling at the time of study, with their timing unclear in relation to the chronology of the drought, and their methodology is often suspect. Different age groups are assessed by different teams, meaning that comparison is made more difficult. Surveyors have also made almost no attempt to measure malnutrition amongst different social groups; unfortunate given that food shortages in famine tend to strike particular social categories in accordance to their relationship to the means of food production and distribution (ie. their 'entitlement', Sen, 1981). Consideration of only the proportion under 80% weight-for-height ignores the nutritional status of better-off sectors of the population. For example, in the data from Harerghe, Ethiopia, (Seaman *et al.* 1978:34), the proportion of children above NCHS standards bears little relationship to the number below 80% of that standard in the sample population. In South Ogaden, for example 23.1% were above NCHS whilst 10.9% were <80%; whilst in contrast only 14.7% were above the standard amongst 'Issa, who had a similar percentage under 80% (8.2%).

Table 5.3.1.1 Weight-for-Height Status in African Drought-Afflicted Populations

	Percentage of Population Below 80% Weight for Height	
	During Famine	**Baseline**
HARERGHE, ETHIOPIA[1]		
May-June 1974, in rains six months after severe drought		
Issa (desert pastoralists)	10.4	
North Ogaden (semi-desert agro-past)	25.2	
South Ogaden (semi-desert agro-past)	12.6	
Marginal (mid-alitude cultivators)	14.2	
Highland (high-altitude cultivators)	19.0	c20.0
WALLO (ETHIOPIA)[2]		
Highland cultivators		
March 1974	1.6 (prob not wt-ht <80%)	
WESTERN SUDAN		
Northern Darfur May/June 1985[3]		
Semi-arid sandy areas	29.0	
Semi-arid alluvial areas	10.0	
Semi-arid nomads	12.0	
Semi-arid sedentary	9.0	
Southern Kordofan[4]		
(Sub-humid, agro-pastoralist)		
May/June 1985	9.0	
Sept/Oct 1985	10.6	
Northern Kordofan[4]		
(Semi-arid, agro-pastoralist)		
May/June 1985	23.2	
Sept/Oct 1985	11.9	
Kordofan (general)[3]		
September 1984	12.9	
February 1985	12-15	
May/June 1985	11-25	
SAHEL (GENERAL)[5, 23]		
Semi-arid past and agro-past		
Mali, Mauritania, Niger and Burkino-Faso (pre-rains 1974)	c10.0	pre-rains 1985: 8.0
Chad (pre-rains 1974)	c20.0	pre-rains 1985 11.8
MAURITANIA		
Semi-arid pastoralist		
1974[6]	17.0	
Settled		
1974[6]	8.0	
1983 (post rains)[21]	8.2 - 17.2	
1983[22]	c15.0	
NIGER/MALI		
Semi-arid pastoralist		
1974[7]	3.4 (under rehab.)	
1980-81[14]		7-17
Semi-arid agro-pastoralists		
1982[15]		20
1981-2[16]		0
1979[17]		5
UPPER VOLTA (BURKINO-FASO)[8]		
semi-arid agro-pastoralist and past.		
July 1973		
Settled	38.0	
Migratory	49.0	

Table 5.3.1.1 Weight-for-Height Status in Drought-Afflicted Populations
Continued

	Percentage <80% wt/ht During Famine	Baseline
SENEGAL		
Ferlo, 1981[18]		4.0
KARAMOJA (UGANDA)[9]		
Semi-arid agro-pastoralist		
Nov-Dec 1980, Kadam County	4.8 (part under relief)	c1.0[11]
1966[10]		1.0[11]
NORTH TESO (UGANDA)[12]		
Sub-humid agro-pastoralist		
December 1980	0.2	c1.0
MOZAMBIQUE		
1983-6 in drought affected areas (also affected by war)		
Missaua (Tete)[13]	12.0	
Ntemangau (Tete)[13]	5.3	
Mutarara (Tete)[13]	1.2	
Chibuto (Gaza)[13]	2.8	
Chicualacuala (Gaza)[13]	4.4	
Vilanculos (Inhambane)[13]	7.8	
Espungabera (Manica)[13]	2.8	
Gaza (displaced)[20]	12.0	
Inhambane (displaced)[20]	28.0	
National Data, 1985-7; 27 surveys[24]	6.0 (range 1-13%)	
Displaced in 1988; 35 surveys[24]	half >10%	
SOUTH AFRICA		
Homeland, 1983 drought[19]	2.0	

Notes to Table 5.3.1.1 (Sources):
1. From Rivers (1988), note that basically the same data are presented in (Seaman *et al*, 1978:34) but the figures are all somewhat different.
2. From Seaman and Holt (1975a)
3. From Rivers (1988) derived from Mohammed (1986)
4. From Shepherd (1988)
5. From Kloth *et al*, (1976)
6. From Greene (1974:1094)
7. From de Ville *et al*, (1977)
8. From Seaman *et al*, (1973), 0-19 year olds
9. From Biellik and Henderson (1981a)
10. From Rutishauser and Whitehead (1969)
11. From Jelliffe *et al*, 1964, and Rutishauser, 1971.
12. From Biellek and Henderson (1981b)
13. From D'Souza (1988:31) quoting a variety of local surveys. War tended to have a more significant effect than drought in these areas. Areas affected only by war have been excluded from this Table.
14. From Loutan (1985).
15. Calculated from Hildebrand (1985:275).
16. From Wagenaar-Brouwer (1985)
17. From Chabasse *et al*, (1985)
18. From Benefice and Chevassus-Agnes (1982)
19. From Kustner *et al*, 1984, calculated as 2SD below standard
20. From Rutherford and Mahanjane (1985)
21. From Warrack-Goldman *et al*, (1986)
22. From Binkin *et al*, (1985)
23. For detailed breakdown of figures see Hogan *et al*, (1977)
24. From Government of Mozambique/World Bank (1989). In the 35 surveys of the 1988 displaced (war and drought affected, receiving food aid and some supplementary feeding), 7 were over 20% (<80% wt/ht), whilst 10 were between 10 and 20% and 18 were less than 10%.

In only a few cases can anthropometric measurements taken during famines be compared with figures for 'normal' conditions in those populations (Table 5.3.1.1). Indeed when they can, the 'normal' levels often make a nonsense of the famine figures (if nutritional status is considered a measure of famine), or at least indicate that there is much variability and frequently very low planes of malnutrition during 'normal' times in some of these places.

It seems sensible to conclude from this little more than that in the semi-arid savannah region droughts may well precipitate conditions where weight-for-height status of children declines, circumstances in which journalists and aid agencies will usually announce famine.

Micro-Nutrient Deficiencies and Drought

Although systematic research on micro-nutrient sources and deficiencies has not been undertaken in Africa, let alone in relation to droughts, a certain amount of literature is available documenting that they can indeed be a problem, especially for the semi-arid savannah populations, as might be expected.

Concern for vitamin A deficiency in drought-affected and displaced populations has become well-established (Rivers, 1988:67-8; *The Lancet* Editorial, 1989). One of the better documented situations was that in the Red Sea Hills (Sudan) during the 1985-7 droughts. Xerophthalmia occurred at levels of 14-37% and Bitot's Spots 4-16% in children; and despite rigorous campaigns to provide vitamin A, levels remained high - even up to 50% in some places (Morton, 1988). (Anecdotal agency reports also recorded vitamin A deficiency amongst the displaced in the Western Sudan during this period.) Pastoralists are often severely affected because they rely on milk as their vitamin A source. Similar, though less serious problems occurred in Mauritania in 1983 (Warrack-Goldman *et al.* 1986:225), once more despite the distribution of prophylaxis. Seasonal increases in viatmin A deficiency are a regular feature in the Sahel pastoralist populations (see Section 5.1).[9] In contrast, amongst Ugandan refugees in the Sudan, night blindness was very uncommon despite the general food situation being bad (Wright and Wilson, in Wilson *et al.*, 1985:108, 67). This presumably reflects the fact that this is a little populated and high rainfall region, where gathered leaf vegetables were comprising an important part of the diet. This suggests that the degree to which milk and vegetable production are vulnerable to drought ecologically, is an important determinant behind vitamin A deficiency levels.

Vitamin C deficiency (scurvy) commonly occurs in famines, except where wild vegetable products are used as a major famine food (Rivers, 1988:64-6). Scurvy occurred during the 1973 Sahel famine in Mauritania (the only area where it was investigated; CDC Final Report, quoted in Sheets and Morris, 1974:133,142; Greene, 1974:1094), and again in the drought of the early 1980s (Warrack-Goldman, 1986:225). Scurvy has also occurred in severe droughts in Southern Africa, for example in the Ciskei (Jelliffe, 1952:27) and Zimbabwe (Nutrition Council, 1948). In recent years it has occurred in a number of refugee camps in the Horn of Africa (Magan *et al.* 1983; CDC, 1989; Seaman and Rivers, 1989; Dr J. Seaman, pers. comm. 1989). It generally erupts in situations where a population is dependent on a narrow food aid diet, and is unable to get access to to the fresh foods they want. Rates of 15% at a population level have been common, with an appalling 28% reached in a camp in Somalia between July and December 1987. It has not been possible to monitor accurately the effects of scurvy on mortality rates in these camps, although good evidence exists for it having increased maternal post-partum mortality in a Somali refugee camp (Seaman and Rivers, 1989). As with vitamin A deficiency, scurvy appears to have been virtually absent in the Southern Sudan (Wilson in Wilson *et al.* 1985:67) because of the high rainfall and abundant available vegetation.

Pellagra commonly develops in populations living on a maize diet (Carpenter, 1981) where severe drought (Nurse *et al.* 1985:184) or displacement and food aid dependence (Medecins Sans Frontieres, 1989, Government of Mozambique, World Bank, 1989) mean that the population loses access to supplementary niacin containing foods such as vegetables. (See also Rivers, 1988:72-3, who stresses that pellagra is rare in famines outside of these conditions).

Beri-beri has been reported for Mauritania during the Sahel famine (CDC Final Report, in Sheets and Morris, 1976:142; Greene, 1974:1094).

The functional impairment and mortality impact of these micro-nutrient deficiencies are examined in Chapter Seven, Section 7.2.2.

The fact that such deficiencies are not unexpected in drought, means that my failure to investigate them in Mazvihwa is unfortunate. However, my impression was that there were not marked effects, and I certainly would have noted - and been informed of - frequent clinical presentation or epidemics of nutrition-related disorders. Nevertheless, field workers must give much more attention to micro-nutrient deficiencies in droughts in future.

5.3.2 Ecological differences in growth rate changes during the 1987 drought

The productivity of the clayveld environment is more vulnerable to drought than is sandveld (Chapters Three and Four), and drought may also worsen 'disease environment' in this zone (Chapter Six). Indeed, cereal consumption was reduced by the drought only in the clayveld sample (Chapter Four, Section 4.2.2). I now present data for anthropometric status of children monitored over this drought period in the two ecological zones and boundary population to test whether status declines most on clayveld.

The children whose growth was monitored during 1986-7 were measured again in January and February 1988. Relative degrees of decline in weight-for-age during the 1987 drought can therefore be examined by comparing individual children assessed in January/February 1987 and January/February 1988. Weight-for-age has been found to be the most powerful predictor of this kind of medium term nutritional stress in a recent Bangladesh study (Bairagi, 1987:265). In order to control for underlying changes in weight-for-age with age, only children over two years old at the first assessment are included, as in this study sample there is no systematic trend with age over two years old (see Methods Chapter).

Table 5.3.2.1 Comparative Weight-for-Age Status of Children
Two to Ten year olds; Jan/Feb 1987 versus Jan/Feb 1988

	Sandveld			Boundary			Clayveld		
	n	wt/age	σn-1	n	wt/age	σn-1	n	wt/age	σn-1
Jan/Feb 1987	7	79.7	7.80	8	86.4	17.29	32	87.7	9.85
Jan/Feb 1988	7	78.4	6.55	8	87.2	17.24	32	83.1	8.54
t-test,		n.s.			n.s.				p<0.01

Numbers of Children with Positive and Negative Changes in Weight-for-Age between Jan/Feb 1987 and Jan/Feb 1988

Sandveld		Boundary		Clayveld	
n +ve	n -ve	n +ve	n -ve	n +ve	n -ve
1	6	4	4	6	26
p=0.06		-		p<0.01	

Notes for Table 5.3.2.1
The probability that 6 out of 7 sandveld children should have declined in status relative to a null hypothesis of equal numbers of positive and negative changes is 8/128, which is p= 0.06 (ie. almost significant at the 5% level). However, this decline is very small (1.3%) and the means are not statistically significantly different.

Boundary population children have apparently not changed in wt/age status. This sample is small due to administrative problems with measuring these children in early 1988.

Clayveld childrens' declines in weight-for-age are considerable, and the means are statistically significantly different. Furthermore the probability that 26 of the 32 children declined in status can be tested against a null hypothesis of 16 such declines (ie. no overall increase or decrease). χ^2 = 6.93, 1df, p<0.01.

A separate test of weight-for-age status of all clayveld children weighed in Jan 1987 versus Jan 1988, which thus includes additional children to the paired sampling (of this table) also produced a statistically significantly different result. The mean percentage wt/age declined from 87.1 to 83.1, t= 1.92, 91df, p<0.05.

The distribution of clayveld children by weight-for-age categories in relation to possible function impairment is presented and discussed in Chapter Seven, Section 7.2.2.

There was a notable decline in clayveld anthropometric (weight-for-age) status between the wet season in 1987 and wet season 1988 (Table 5.3.2.1). It is also possible that sandveld children have declined during the same interval, but the sample is too small to be certain. In those sandveld children for whom data is available the decline itself was negligible. Boundary population children do not seem to have changed in anthropometric status in this time period. This would apparently confirm that clayveld children are more vulnerable to the effects of drought than those of boundary and sandveld. This was the explanation given by the people involved. Although I did not weigh adults systematically, people certainly looked thinner in 1988 than they had in 1985 and 1986. Clayveld residents stated that this was because of diet inadequacy over the drought years.

One problem for the interpretation of this result is whether the declines observed in 1988 are a function of the prolonged drought since the 1984-5 harvest, or whether the declines reflect the fact that precipitation in the 1988 wet season was three times that in the rains of 1987.

The mild sandveld decline - not matched in the boundary population - might be a function of the fact that the wetter the wet season the worse the disease environment and hence anthropometric status in this particular ecological zone (see Section 5.3.1 and Chapter 6, Section 6.2.1). Thus it may have been the wetness of January-Februray 1988, rather than the dryness of the 1985-7 period that caused the slight decline in nutritional status in sandveld during the period monitored. Data from Road to Health cards for the adjacent Mutambe sandveld area did suggest that nutritional status was lower in the rainy seasons of wet years than in dry years (unpublished).

A similar argument could (unfortunately) be advanced for clayveld, since during the wet season in years of high rainfall my evaluation of growth rates from 1981-5 showed that there is typically low growth velocity in such years (Section 5.2.5). However, more detailed consideration of the evidence identifies that the wet years from which high rainfall wet season growth rates were derived were both wet years that followed dry years (1981 and 1985). Therefore decreased growth during these previous years could equally well reflect this 'drought' factor, as it could any elevated morbidity or agricultural labour. A full assessment of the effect of wet years on seasonal weight gain will not be possible unless research is conducted during a time when rainfall is in a high stage in its 'cycle', that is during the mid 1990s (Tyson, 1978).

5.3.3 Differential recovery from drought after the 1988 harvest

This section compares the changes in anthropometric status of the children in the three zones after the good harvest of 1988 which ended the period of dearth. It is hypothesised that clayveld children in particular will be able to capitalise most on this, improving most rapidly in weight, 'compensating' for the depressed growth rate during the period of drought.

Sandveld children usually improve in nutritional status in the dry season, whilst clayveld children tend to decline (Section 5.2). Therefore, if clayveld children gain in weight-for-age status more than those of sandveld and boundary it indicates that the inter-annual effect is highly significant.

Table 5.3.3.1 compares paired assessments of weight-for-age from children measured both in January/February and in June/July 1988. These children are largely, but not precisely, the same children in the analysis of paired weight-for-age assessments described in Table 5.3.2.1.

The data for change in weight-for-age standards (Table 5.3.2.1) suggest that there have been improvements in all three populations with the harvest of 1988. In the boundary and sandveld populations this improvement is slight and may correspond simply to that expected at this time of year (post-harvest and dry season) in these zones (see Section 5.2). In clayveld, however, the improvement is considerable, and is counter to the usual decline in status into the dry season (Section 5.2). The improvement is sufficiently compensatory to return the children to a mean weight-for-age status slightly above that for the start of the drought period (July 1986: see Table 5.2.2.3), making up for the period of decline that has occurred during the drought.

Table 5.3.3.1 Comparative Weight-for-Age Status of Children Two to Ten Year Olds Gaining Weight After Drought; Jan/Feb 1988 versus Jun/Jul 1988

	Sandveld			Boundary			Clayveld		
	n	wt/age	σn-1	n	wt/age	σn-1	n	wt/age	σn-1
Jan/Feb 1988	9	77.1	6.55	8	88.8	16.39	39	83.8	8.96
Jun/Jul 1988	9	80.2	6.23	8	90.5	12.41	39	89.6	10.91
t-test,		n.s.			n.s.			p<0.01	

Numbers of Children with Positive and Negative Changes in Weight-for-Age Status after the Ending of Drought between Jan/Feb 1988 and Jun/Jul 1988

Sandveld		Boundary		Clayveld	
n +ve	n -ve	n +ve	n -ve	n +ve	n -ve
7	2	7	1	32	7
p=0.06		p=0.04		p<0.01	

Notes for Table 5.3.3.1
Sandveld children have not increased significantly in weight-for-age (t= 0.979, 16df, n.s.). However, an increase in status of seven out of nine children is almost statistically significant (28/512= 0.055).

Boundary children have marginally increased in weight-for-age status, and this is not statistically significant. Yet the improvement in status of seven out of eight children is significant, as this has a probability of 9/256 (p= 0.035).

Clayveld children have improved markedly in weight-for-age status, (t= 2.54, 76df, p<0.01). Furthermore the probability that 32 out of 39 children improved in weight-for-age status can be tested against the null hypothesis of an equal number of increasers and decreasers. This is highly statistically significant (χ^2= 8.93, 1df., p<0.01).

Growth Velocity After the 1988 Harvest

Weight gain following the 1988 harvest can be compared for children in the different zones to test whether the clayveld children do indeed gain more than NCHS standard rate of weight-gain (2.2kg/year), and more than the children in boundary and sandveld populations.

Method of data analysis
Table 5.3.3.2 presents mean weight gain velocity data for children aged one to seven years in the three populations between January and June 1988 (clayveld) and February and July 1988 (sandveld and boundary). Sandveld and boundary have been combined due to small sample size. The method of analysis is identical to that described in previous growth velocity analyses (see 5.2.3.1, 5.2.3.2 and 5.2.5.1). Children of this particular age (1-7) are required to gain 2.2kg/year to maintain NCHS standards. Weight velocity is probably the best measure of short term changes in nutritional status (Bairagi, 1987:265).

Table 5.3.3.2 Weight Gain Velocity Post-Harvest 1988, one to seven year olds

	Sandveld + Boundary			Clayveld			Prob.
	n	wt/vel (kg/yr)	σ_{n-1}	n	wt/vel (kg/yr)	σ_{n-1}	
Jan/Feb - Jun/Jul	12	2.5	2.33	45	4.00	2.50	$p<0.05$

Clayveld weight gains are indeed statistically significantly greater than those of boundary and sandveld populations. Furthermore, rates of weight gain on sandveld and boundary are only slightly above 'expected' velocities on NCHS standards, and presumably reflect the usual seasonal improvement at this time of year (Section 5.2), whilst clayveld gains are nearly double the velocity necessary to maintain NCHS standards and are unseasonal. Therefore the weight-velocity analysis supports the notion that drought had induced depression of growth rate on clayveld, and that with high rainfall a compensatory response had occurred.[10] In contrast no such effect was evident in sandveld and boundary populations.

Conclusions to Section 5.3

In a review of available studies on the effect of drought on nutritional status in Africa a certain amount of evidence was found indicating that protein-energy and micro-nutrient malnutrition can increase at times of low rainfall, most especially in the semi-arid savannahs. Despite the near total lack of data, it was also suggested that in the moist savannahs low rainfall has a less significant impact on child growth, and possibly even a positive effect; this is caused, it appears, through improvement of 'disease environment' and lower vulnerability of production. In recognition of the ecological differences between the environments under study (Chapter Three), and the effects that this has upon food production (Chapter Four), it was therefore possible to predict that nutritional status on clayveld would be much more vulnerable to drought (and elevated by good rainfall) than would be the case in the sandveld and boundary populations. This hypothesis was tested by examining declining weight-for-age status during the severe drought year of 1987; and then by seeking evidence of 'compensatory' growth responses in the aftermath of the high rainfall in the 1987-8 rainy season. Both investigations supported the predicted pattern, overcoming other seasonal and inter-annual factors.

5.4 Concluding Discussion to Chapter Five

This chapter represents the first attempt to derive seasonal and inter-annual variations in birthweight and child growth within a single study in Africa, and, more important, to show that populations in adjacent environments with the same climatic regime actually display contrasting patterns of nutritional stress because of differences in underlying ecological dynamics. In sandveld nutritional stress is greatest during the rainy season, whilst in clayveld declines occur in the dry season. Droughts appear to depress birthweight and growth only in clayveld; and in contrast it is years of high rainfall that may paradoxically be times of greater nutritional stress in sandveld. An agro-ecosystem distinction of this type thus enables more rigorous identification of the determinants of seasonal and inter-annual variation in welfare stress in savannah environments. On the basis of this ecological insight I have shown through literature review that there are actually not one but two broad seasonal and inter-annual nutritional regimes in savannah environments, distinguished at a macro-scale by rainfall, and at a micro-scale by differences in soil and hydrology that have similar effects as being 'arid' versus 'moist' on plant productivity and disease environment.

CHAPTER SIX
ECOLOGICAL DYNAMICS OF MORBIDITY

Introduction

The ecological differences between the clayveld and sandveld, which are based upon soil type (Chapter Three), have been shown to lead to contrasting patterns of seasonal and inter-annual food production and consumption (Chapter Four), and birthweight and growth (Chapter Five). This chapter first investigates whether these ecological contrasts are further reflected in seasonal and inter-annual patterns of morbidity, and then explores interactions between morbidity and water supply and nutrition.

Sections 6.1 and 6.2 investigate evidence for contrasting seasonality and inter-annual variations in disease patterns. I begin by showing that the so-called "typical" seasonality of elevated wet season morbidity in savannahs is probably only the pattern in the moister savannah areas. In the arid savannahs the hot dry season is suggested as the period of highest morbidity. As clayveld and sandveld savannahs function ecologically as arid and moist savannahs respectively (Chapter Three), this comparative perspective is then used to construct the hypothesis that clayveld will show elevated dry season morbidity whilst sandveld shows a wet season elevation in morbidity. Child morbidity levels based on recall from past week, on a bimonthly basis over two years are used to test this hypothesis, together with some data from local clinic attendance. In Section 6.2 the child morbidity data are used to investigate inter-annual variation. There are virtually no studies providing information on inter-annual variation in morbidity, on which to base hypotheses. However, on the basis of the seasonality data, the behaviour of these environments under inter-annual rainfall variation (Chapter Three) is used to predict that morbidity will be relatively elevated in clayveld in 'droughts' and in sandveld in a wetter years. The data that I have available are then used to test whether there are differences in the levels of morbidity between the wet and dry years monitored. This material then affords a basis for examining inter-annual mortality rates in Chapter Seven.

Section 6.3 addresses the degree to which water supply differences between zones and between kitchens affect morbidity, and subsequent anthropometric status and mortality. These factors combine ecological contrasts, local differences (borehole access) and economic differentiation, linking Chapter Three with Chapter Eight. In the final Section (6.4) interactions between morbidity and anthropometric status are used to link this chapter with material on food production (Chapter Four) and growth (Chapter Five); and providing a foundation for exploring the nature and causes of differentiation effects upon welfare (Chapter Eight), and historical changes in welfare (Chapter Nine).

6.1 Seasonal Dynamics in Morbidity

6.1.1 Review of existing material on disease seasonality in savannah Africa

Introduction

Disease seasonality in African savannah environments is still incompletely known, though a number of excellent case studies have been made. I use these studies below to suggest that the wet season morbidity elevation considered typical of savannahs is actually the situation only in the 'moist' savannahs (over 500 to 600mm rainfall). In contrast the information for semi-arid savannahs suggests that morbidity is elevated in the dry season in these areas (except, where they are hot and/or wet enough for malaria, which remains significant in the late wet season). Soil-moisture relations of clayveld create a disease environment of the 'arid savannah' type, whilst upon sandveld the pattern resembles that of the 'moist savannah'.

Data on morbidity seasonality for Zimbabwe

Apart from the considerable epidemiological research conducted in parts of Zimbabwe on schistosomiasis (eg. Chandiwana, 1987), malaria (Taylor and Mutambu, 1986) and trypanosomiasis, and some work on intestinal helminths (Goldsmid, 1972), there has been little if any consideration of seasonality and inter-annual variation in morbidity within Zimbabwe.[1] Notable is the the omission of work on the seasonality of the major diseases affecting African children: diarrhoea, pneumonia and ears, nose and throat problems, sore eyes, measles and whooping cough.[2] There are, however, some observations on disease seasonality from a Mission Clinic in the study region from the 1920s and 1930s;[3] and the early colonialists recorded higher malarial and diarrhoeal levels in the rains, especially in the vicinity of (sandveld) dambos.[4] Lack of sufficient Zimbabwe data means that studies from other African savannah areas therefore need to be reviewed in order to frame hypotheses about seasonality of these ailments in the Mazvihwa study area.

General morbidity patterns in moist and arid savannahs

Research in a number of savannah areas in Africa have led to a general recognition of the wet season as typically the period of elevated morbidity. The studies of the MRC/Dunn Nutrition Unit in the Gambia have been particularly influential (eg. McGregor *et al.*, 1970; Thompson, 1977; but other studies have suggested generalisation from this pattern: Poskitt, 1972 and Waldemann, 1973). There are many reasons why warm/hot moist conditions and high humidity favour disease transmission (Bradley, 1981:130), including increases in the number of biting dipterans (McGregor 1976:182). In contrast the dry season temperatures are mild/warm and the land dry. Susceptibility to infection may also be higher in the rainy season in these areas, notably due to the marked declines in nutritional status (cf. sandveld in Chapter Five); (Bradley, 1981:130, Harrison, 1988). The dry season is a period of an abundance of food in these environments as it follows the harvest. In the moist savannah regions the dry season is not sufficiently long to exhaust the harvest prior to the onset of rains. Furthermore in these regions there remain 'bush foods' in the dry season to maintain dietary diversity (Chapter Four and Appendix One). Freed from agricultural labour people gain weight rapidly (Chapter Five).

The above factors responsible for the elevation in wet season morbidity may only operate in moist savannah situations. In the more arid savannahs (under 500mm annual precipitation) conditions are not as moist in the 'wet season' and therefore do not give such advantage to disease transmission at this time. Furthermore the dry season is much more marked and longer. Dust presents a problem due to the extreme desiccation, and the dry season is often very windy. In the Sahel there is the harmattan, and in southern Africa July, and also August, are characteristically very dusty and windy. Glare from cloudless skies and sun bleached land can trouble eyes. In the moister savannahs, soon after the sun begins to return overhead the rains significantly lower the temperatures through cloud cover and evaporation. In the arid savannahs the heat is particularly oppressive in this period of the dry season in the two or so months before the rains. As the drier savannahs are further from the equator (dry lowlands of East Africa excepted), the dry season also includes a time of intense cold in its earlier part, and leads to crowding (at times in smokey huts). These extremes of heat and cold, exacerbate physiological stress on the populations. Dry season declines in nutritional status in the more arid savannahs (Chapter

Five) may increase susceptibility to infection, and also the severity and duration of morbidity. In contrast to the moist savannahs, the rains bring an improvement in anthropometric status in the arid savannahs (Chapter Five).

The only full epidemiological study in a semi-arid savannah in Africa encompassing a range of common ailments and comparing morbidity on a seasonal basis is the Kenya/Dutch study of Machakos (van Ginneken and Muller, 1984). Yet because this study is in an equatorial, two-rainy seasons per year region, it cannot be strictly compared to the tropical arid savannahs such as southern Zimbabwe or the Sahel. The only quantitative study of such an arid savannah zone I have located is Hildebrand (1985:274-281). This is a year long study of communities in Mali, relying, like me, on self-reporting of symptoms. She recorded some evidence of elevated morbidity in all populations in the dry season, especially the cold part of the dry season, but there was also a malarial peak at the end of the rains.[5]

There are observations from medical personnel and researchers that support this picture of a dry season morbidity peak in the semi-arid savannahs. Bernus (1988:331-2) remarks on late rains malaria in the Sahel, but notes the high level of ENT infection in the cold dry season, and that the hot dry season experiences the highest overall morbidity. A physician in eastern Zimbabwe who ran the Mt Selinda and Chikore hospitals from 1958-69 observed on clinic visits a dry season morbidity peak and that this was much more marked in the semi-arid Sabi-valley (clayveld/mopane) area (Donaldson, 1984:201). An epidemiological cross-sectional survey in the hot dry season in Mali (Chabasse *et al.* 1985) did record high morbidity, but is not in a position to compare this with other seasons, though they felt that it was a time of stress. In contrast a forty-day health mission amongst the Sahelian Tuareg believed that diarrhea, ear/nose/throat and broncho-pneumonia increased with the coming of the rains (Epelboin and Epelboin, 1976:251).

The discussion above demonstrates that climatic factors of temperatures and precipitation drive much of the seasonality in morbidity in savannahs. Yet these macro-level climatic factors do not control all the factors influencing disease vectors and susceptibility. If climate alone controlled disease seasonality both ecological zones in my study area would show the same seasonality of disease. On the contrary it is shown in this chapter that the sandveld follows the 'moist' savannah pattern and the clayveld the 'arid' savannah pattern. Theoretical justification for considering that the zones are behaving in the manner of 'moist' and 'arid' savannahs is now presented.

Chapter Three has shown that soil type plays an intervening role between climate and the lived environment as experienced by people. In addition to the impact upon ecological productivity, hence food and nutritional status (Chapters Three, Four and Five), soil type also influences the behaviour of surface water, and hence it affects the 'disease environment'. During the dry season the clays dry out much more quickly and retain lower plant and litter cover. Additionally the soil is much finer textured. This leads to much worse dust in the clayveld than sandveld. During the wet season, clayveld run-off is largely lost to streams, whilst in the sandveld dambo wetlands tend to flood, especially during periods of high rainfall (Chapter Three). People are in close contact with these swamps, as they farm the dambos (Chapter Three), and collect their domestic water from them (Section 6.3 this chapter). They also generally live close to their wetland fields in this sandveld study area (partly to protect their fields from baboons). The adage of plant ecologist Walter (1971) may be useful here to dispel the concept of clay soils being wetter than sands during rainfall. Walter observed that clays are only "wetter" than sands/loams in circumstances of high rainfall (and/or low evapo-transpiration); in contrast clays are drier than sands when there is little moisture available.

The specific epidemiology of each four main contributors to child morbidity (diarrhoea; sore eyes; ear, nose and throat [ENT]; and measles) is reviewed in relation to these environmental factors in the appropriate sections below.

6.1.2 Contrasting Seasonality in Overall Morbidity 1986-7

Child morbidity data

This analysis compares the overall proportions, by season, of children 'morbid' versus 'healthy'. As explained in the Methods Chapter these definitions are those of the mothers, and the data is of an incidence-prevalence form, as it comes from weekly recall data, on a collected bimonthly basis.

Table 6.1.2.1 presents the morbidity data pooled by season. Clayveld children show significantly higher morbidity during the dry season than they do in the rainy season. During the rainy season sandveld children show higher morbidity than the clayveld. In the sandveld, rainy season morbidity is also higher than that in the dry season in the sandveld, but the result is not statistically significant. The boundary population shows an intermediate pattern (see Graph 6.1.2.1).

Table 6.1.2.1 Morbidity rates in wet and dry seasons: contrasts between clayveld and sandveld children, 1986-7

	Sandveld			Clayveld			χ^2, 1df
	N. morbid	N. sample	% morbid	N. morbid	N. sample	% morbid	
Dry:	9	21	42.9	73	130	56.2	1.3 $p<0.3$ ns
Rains:	36	65	55.4	74	204	36.3	7.5 $p<0.01$
χ^2, 1df;	1.0, p= 0.3 n.s.			12.7, $p<0.001$			

Notes to Table 6.1.2.1:
Dry season in 1986-7 data is the months Jul/Aug and Sep/Oct
Rains in 1986-7 data refer to time intervals Nov/Dec and Jan/Feb

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Analysis of seasonal morbidity patterns using only 'medium' and 'serious' levels of morbidity, (and not 'mild'), showed that the contrasting seasonality pattern was maintained but with a non-significant result. Use of only a 'core sample' of children for whom there were records at each time interval produced similar results to Table 6.1.2.1, but only one result was statistically significant.

Sandveld Clinic Attendance Data

Data from the Mutambe Clinic, which serves the sandveld population, is available for 1987 calender year, and is presented in Graph 6.1.2.2.

Notes on the preparation of Graph 6.1.2.2
Data in Graph 6.1.2.2 is for attendance of children under five years of age, as over fives are pooled with adults. Morbidity from the following disease categories was used to calculate the attendance rate under general morbidity: measles, whooping cough, diarrhoea, malnutrition, malaria, respiratory diseases, eye problems, skin diseases and scabies. Diarrhoea and respiratory diseases dominated morbidity. Percentage morbidity at each month interval means the proportion of total clinic attendance for that year recorded in that month; it does not therefore represent a figure of population infection incidence. The total attendance to the clinic in these year, age and disease categories was 1120.

Mutambe clinic data (Graph 6.1.2.2) support the evidence that there is higher child morbidity during the rainy season than in the dry season in sandveld populations. Comparative data is not available for a clinic on clayveld. It is unlikely that the pattern of the Mutambe data is driven by higher attendance per incidence of illness in the wet season, because (of course) people are much busier with agriculture in the rainy seasons.

FIG 6.1.2.1 SEASONAL CHANGES IN OVERALL MORBIDITY 1986 - 1987.

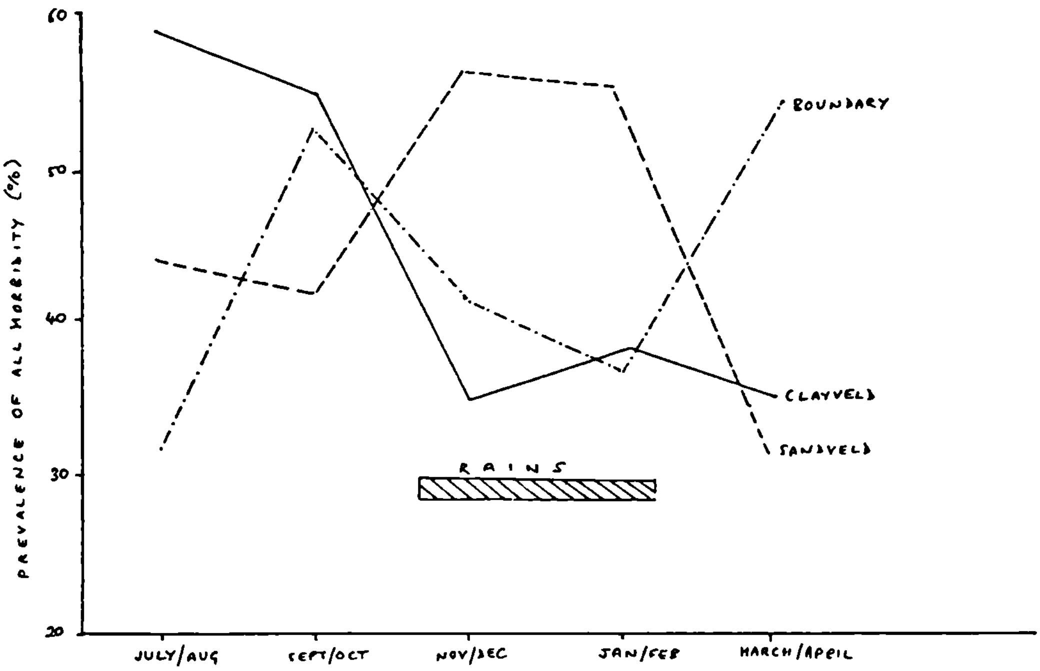
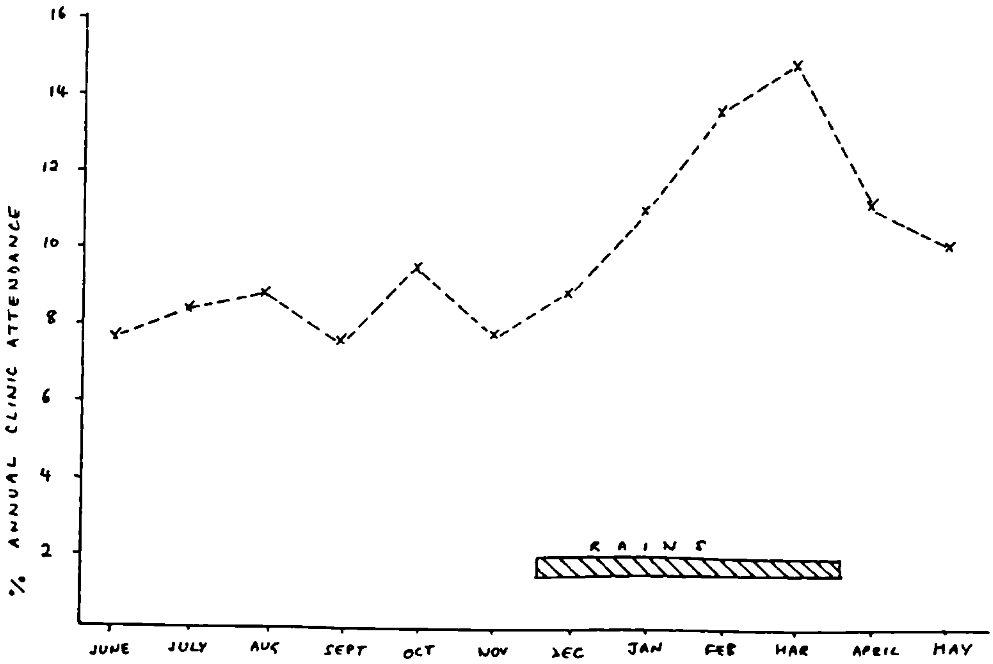


FIG 6.1.2.2. OVERALL MORBIDITY: MUTAMBE (SANDVELD) CLINIC DATA, 1987



6.1.3 Seasonality in Overall Morbidity in 1987-8

Morbidity levels in 1987-8 are now assessed for the same children that were monitored in 1986-7. In this section differences in seasonality are considered. Differences in overall level are considered in Section 6.2.2.

Table 6.1.3.1: Morbidity in wet and dry seasons: seasonality contrasts between zones, 1987-8

	Sandveld 1			Sandveld 2			Boundary			Clayveld		
	N Morb	N Samp	% Morb	N Morb	N Samp	% Morb	N Morb	N Samp	% Morb	N Morb	N Samp	% Morb
Dry	11	38	28.9				20	79	25.3	25	80	31.3
Rains	11	34	32.4	83	169	49.1	37	79	46.8	50	109	45.9
χ^2, 1df		n.s.						7.9 $p<0.01$			4.1 $p<0.05$	

Notes to Table 6.1.3.1:
Dry season in 1987-8 data refers only to the end of the hot dry season: Nov/Dec 1987
Rains in 1987-8 data refers to Jan/Feb 1988
Sandveld 1 is the normal Mototi sandveld sample
Sandveld 2 is a one-off survey in a neighbouring Mutambe Ward Vidco

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The above data show a contradictory pattern to that collected in 1986-7 (Section 6.1.2). Clayveld morbidity rises in the rains rather than falls as had been predicted. Boundary population morbidity also rises in the rains of 1987-8, rather than remaining relatively constant. Sandveld morbidity, however, rises little with the rains, in contrast to the major increase expected. During the dry season sandveld morbidity was expected to be higher than clayveld; in fact it was slightly lower. However, the one-off field survey in Mutambe sandveld area did show a high rainy season morbidity rate comparable to the rates obtained in this sandveld zone in Mototi in 1986-7. Although rainfall was higher in 1987-8 than 1986-7, there is no ready explanation of this difference. It had been predicted that under high rainfall morbidity would be elevated in sandveld rather than clayveld. A possible explanation may lie in restriction of dry season data to right at the end of the dry season, as rains were breaking.

6.1.4 Diarrhoeal Seasonality

Aetiology, epidemiology and seasonality of diarrhoea in savannah systems

Studies of the seasonality of diarrhoea have to recognize that different causative agents are likely to have different seasonalities. I start, therefore, by reviewing what is known about causative agents in Zimbabwe and their seasonality. There has been only one published study of diarrhoea in the Communal (peasant farming) areas of Zimbabwe (Mason *et al.*, 1986), but it does not state season or year of survey, or relate the intestinal parasites found to diarrhoeal morbidity. Therefore I utilise studies in urban and estate farm worker communities.

It is recognized that there are rather distinct summer and winter diarrhoea types in Southern Africa. Jones (1967:252), then a paediatrician at Mpilo Hospital, Bulawayo, mentions 'summer diarrhoea' as a feature of growing up in Southern Africa. Summer diarrhoea is associated with bacterial and protozoal pathogens *Shigella*, *Salmonella*, *Escherichia coli*, *Campylobacter jejuni*, and *Giardia lamblia*, (Zilberg, 1976; Nathoo *et al*., 1986; Simango and Dindiwe, 1987). Each of these studies obtained rather different results but the overall picture is fairly conclusive.[6] The pattern of diarrhea causality in Zimbabwe is generally similar to that obtained in Johannesburg (Frieman *et al*. 1977; Bokkenhauser, 1979; Mauff and Chapman, 1981; Robins-Browne *et al*. 1980).

Intestinal helminths are not very common in Zimbabwe compared to some third world areas.[7] Research in Zimbabwe (Goldsmid, 1972:5) has found that hookworm and *Ternidens deminutus* infestation increases during the rainy season. Such infection would be expected to increase gastro-intestinal disruption. Wet season malaria and typhoid frequently present with diarrhoea, amongst other symptoms, (Gelfand, 1983:238); the former has a prevalence of only about 2% and an annual incidence of 30/100000 in the actual area under study (from map in Taylor and Mutambu, 1986), the latter is more common but has apparently not been researched. Zvishavane District Hospital has noted an association between the use of Lundi River water and typhoid infection in this district (Dr Ndhlovu, pers. comm. 1987).[8]

Detailed studies in Zimbabwe have shown that winter diarrhoea in both blacks and whites is associated with rotavirus (Cruikshank *et al*., 1974; Cruickshank and Zilberg, 1976; and Cruikshank *et al*., 1976), a cold season rotaviral peak has been found in many parts of the world (Cutting, 1981).[9] Privileged urban whites in Zimbabwe tend to show overall winter peaks in Zimbabwe (Zilberg, 1976:2039), although overall levels of morbidity are much lower as rotaviral infections have proven more resilient to interruption than those caused by bacteria and protozoans.

A hot rainy season peak in diarrhoeal morbidity is generally considered typical in savannah Africa, and elsewhere (eg. in a part of Latin America, Delgado *et al.*, 1983:233). Valdemann (1973:431) reports a gastroenteritis peak in hospital admissions during the hot rainy season in Sekhuniland (north eastern Transvaal) during 1957-62, and diarrhoea was most frequent in the late rainy season in Lesotho (Drasar *et al.* 1981:108). Wet season peaks have been closely documented in the Gambia (McGregor *et al.*, 1970:53-4; Tomkins *et al.* 1986:541); in Johannesburg (Robins-Browne *et al*, 1980); in Bagamoyo, Tanzania (Goetz, 1981:181-5); in Uganda (Poskitt, 1972; Cole and Parkin, 1977); in Cameroun/Chad (De Garine and Koppart, 1988:230), and in northern Nigeria (Tomkins, 1979a; and 1981:178).

The association between the rainy season and elevated diarrhoea is often accounted for by the notion of a flush of faecal material into water supplies. Yet any effect of faecal flushes with the rains might well be expected to be counteracted by declines in water quality and quantity available in the dry season. In practise, however, much diarrhoea is actually transmitted independently of water supply (see, for example, Drasar *et al.* 1981:107-9). Drasar *et al.* (1981) point out that empirical work by one of them in New Guinea found that the contaminated flush was very temporary whilst the elevated diarrhoea persisted for much longer. Other work by Feachem *et al.* (1978) into wet season peaks of diarrhoea and typhoid in Lesotho illustrates this lack of clear relationship between diarrhoea and rainfall further. Levels of faecal coliforms and streptococci were indeed five times higher in the wet than dry season; diarrhoea, however, only increased well into the rains, and the typhoid component of this was in fact not water-borne at all. To cap it all, a study of an urban Gambian population with potable water still showed a strong hot wet season peak in gastro-enteritis (Tomkins *et al.* 1986:541).

Data presented in this section suggest that in fact in this Zimbabwean population there is a rise in diarrhoea before the onset of the rains, and interviews with women suggest that this is the normal pattern (see below). Dean and Jones (1972) in a careful study of American military personnel in the Philippines also noted that there was a rise in diarrhoea before the rains broke, at that very hot time of year. However, they did not find elevated diarrhoea among indigenous Philippinos until the rains actually broke. Morgan (1977:3), in studies of fly output from pit latrines in Harare during 1974 and 1975, showed that fly populations only increase with the break of the rains, even from the (moist) pit latrines. Though he observes: 'often peak periods of fly emergence coincide with high transmission levels of several enteric diseases'; increases in fly populations cannot therefore explain why diarrhoea increases with the hot season prior to the rains in Zimbabwe.

Research in Africa has yet to identify exactly how important are the different infection routes/causes of diarrhoea associated with these agents. However, there is a suggestion that elevated temperature rather than rainfall is responsible for seasonality in diarrhoea. More rapid contamination of food due to greater multiplication rates of pathogens in warmer weather may be a significant cause of hot-wet season diarrhoeal peaks (Drasar *et al.* 1981:105). (Fridges appeared to have particularly marked diarrhoea-reducing effects beyond their role as socio-economic indicators in a Northern Sudanese study [El Samani, *et al.* 1988:104]). Of more general importance, weaning foods in the Gambia have been shown to be frequently contaminated by being kept for some period after cooking. Pre-preparation and hence contamination is especially marked in the rains as the mothers are then extremely busy in the fields (Rowland *et al.* 1978). Feeding is altogether more haphazard at this time of year (Rowland and McCollum, 1977:200.[10] Indeed a careful study in Bangladesh demonstrated that levels of weaning food contamination with *E. coli* followed the same seasonal cycle in temperatures as did diarrhoea with this agent, and that the proportion of a child's food samples containing *E. coli* was significantly related to the child's annual incidence of diarrhoea associated with enterotoxins (Black *et al.*, 1982).

Studies in areas where peak temperatures and rainfall do not coincide support the hypothesis that it is temperature rather than rainfall seasonality that is responsible for elevating diarrhoeal levels. A study in Imo State, southern Nigeria is a case in point. In this West African forest belt the rainy season is associated with a drop in temperature due to increased cloud cover (and the influence of sea winds?). Child diarrhoeal morbidity was lower in the rainy season than dry season (Hoskins, 1988; Huttly *et al.*, 1987:866). Hoskins interpreted this as being due to a dilution of pollution in water supplies during the rains and apparently there may be such a cycle in contamination (Huttly et al., 1987:866). However, the notable factor that is different in this area to the wet season peaks of the adjacent moist savannah belt is that temperatures are lower in rains in the forest belt. North of the moist savannah in West Africa climate seasonality changes once more so that much of the dry season is hotter than the (shorter period) of rains. It is only in this arid savannah zone that (hot) dry season peaks in diarrhoeal morbidity have been observed, that is in the Northern Sudan (El Samani: *et al.*, 1988:98-9,103),[11] the Mali study by Hildebrand (1985:281),[12] and a study in Niger by Loutan and Lamotte (1984:947).[13] A fourth semi-arid savannah study was made in Machakos, Kenya, (Leeuwenburg *et al.*, 1984a). The lack of sharp seasonality in Machakos presumably reflects the two rainy-season equatorial regime, and the researchers could find no ready explanation for the observed pattern.

Tomkins (1979) has suggested that folate deficiency (due to lack of green vegetables at the break of the rains together with seasonal weaning) is responsible for enhancing physiological vulnerability to diarrhoea (this and related possibilities are discussed by Drasar *et al.*, 1981:109-11). Such an effect could have contributed to explaining the increase prior to the rains in Mazvihwa (as vegetables do get in short supply), but if this factor is important there would have been differences in seasonality between ecological zones as the dry season has a less serious effect on vegetable availability in sandveld. However, green vegetable availability rapidly becomes very high throughout the rains in rural Zimbabwe (and presumably northern Nigeria), and hence this cannot explain the persistence of diarrhoea through the rains in these areas.[14]

Hypotheses for diarrhoea seasonality in the Mazvihwa sample

If diarrhoea seasonality is indeed driven by temperature there should be no difference in the seasonalities between the ecological zones in this case study. If nutritional factors, such as consumption of greens, are important then the sandveld should show less morbidity in the hot dry season than the clayveld. If water supply factors are at all significant then there might be substantial differences in morbidity levels and seasonality, because, as theorised in Chapter Three and detailed in Section 6.3, water supply is different between zones.

Child morbidity data from the Mazvihwa study

Seasonality of diarrhoeal morbidity for 1986-8 is shown in Table 6.1.4.1. There is very little difference in seasonality between the three zones. There is apparently a general rise in diarrhoea prevalence-incidence in the hot dry season through the main rains.

Table 6.1.4.1 Diarrhoeal seasonality in 1986-8

	Sandveld 1			Sandveld 2			Boundary			Clayveld		
	N Diar	N Samp	% Diar	N Diar	N Samp	% Diar	N Diar	N Samp	% Diar	N Diar	N Samp	% Diar
Cold Dry	3	46	6.5				5	87	5.7	9	131	6.9
Hot Dry	5	50	10.0				16	143	11.2	20	178	11.2
Rains	12	99	12.0	21	169	12.4	33	229	14.4	36	313	11.5
Harvest	4	63	6.3				11	104	10.6	25	196	12.8

Notes to Table 6.1.4.1:
Cold dry season refers to July/Aug in 1986 and 1988
Hot dry season refers to Sept/Oct 1986 and Nov/Dec 1987 (rains started later in the latter year)
Rains refers to Nov/Dec and Jan/Feb 1986-7 and Jan/Feb 1988
Harvest refers to Mar/Apr in 1987 and Apr/May 1988
Sandveld 1 is the normal Mototi sandveld sample
Sandveld 2 is a one-off survey in a Mutambe Ward Vidco in Feb 1988

Combined cold dry season data from 1986 with 1988, contrasted with hot dry season and wet season data from 1986, 1987 and 1988 for all zones pooled: cold dry season 6.4%, hot dry plus wet 12.1%, χ^2, 1df, 6.79, $p<0.02$.

Harvest-season data for Apr/May 1988, with zones pooled, show a mean level of 16.6% diarrhoea as compared to 4.4% in Mar/Apr 1987; which is highly statistically significant (χ^2, 1df, 13.9, $p<0.001$).

The cold season shows lower diarrhoeal morbidity than the hot season in all populations. This is true both before and after the break of the rains. This result supports the hypothesis that temperature is indeed the most significant causal factor in diarrhoeal seasonality.

Harvest-season diarrhoeal morbidity is much lower in 1987 than 1988. There are two possible explanations for this. First the rains were heavier and continued for much longer in 1987-8 and this meant that levels of diarrhoea remained elevated for longer. This argument requires that elevated diarrhoea is related to rainfall, rather than temperature, which seems unlikely. A more probable explanation is that diarrhoea is promoted by excess harvest-product consumption (see below) in this second year when there was a much larger harvest. This draws attention to the multiple aetiology of diarrhoeas.

FIG 6.1.4.2 SEASONALITY OF DIARRHOEA : MUTAMBE (SANDVELD) CLINIC DATA, 1987

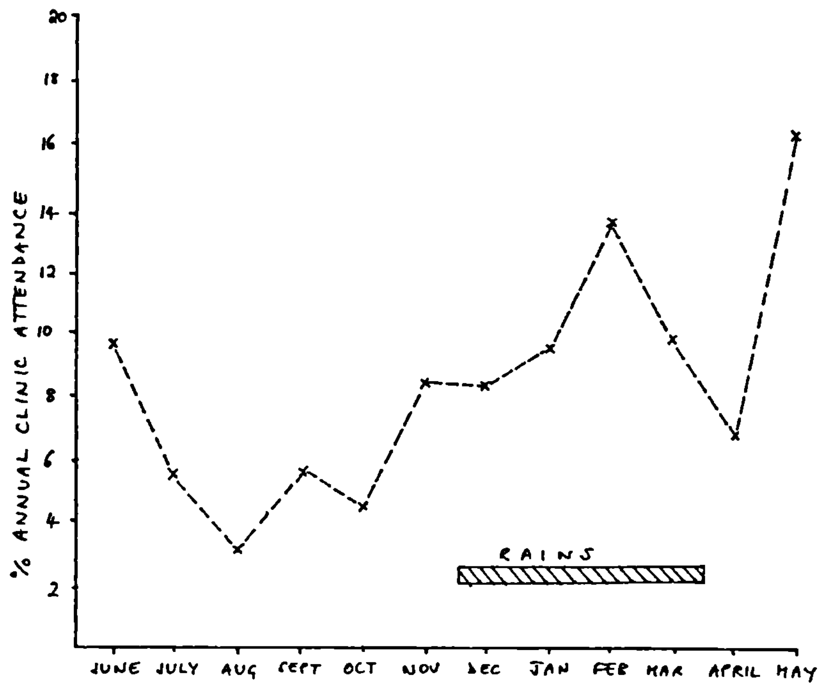
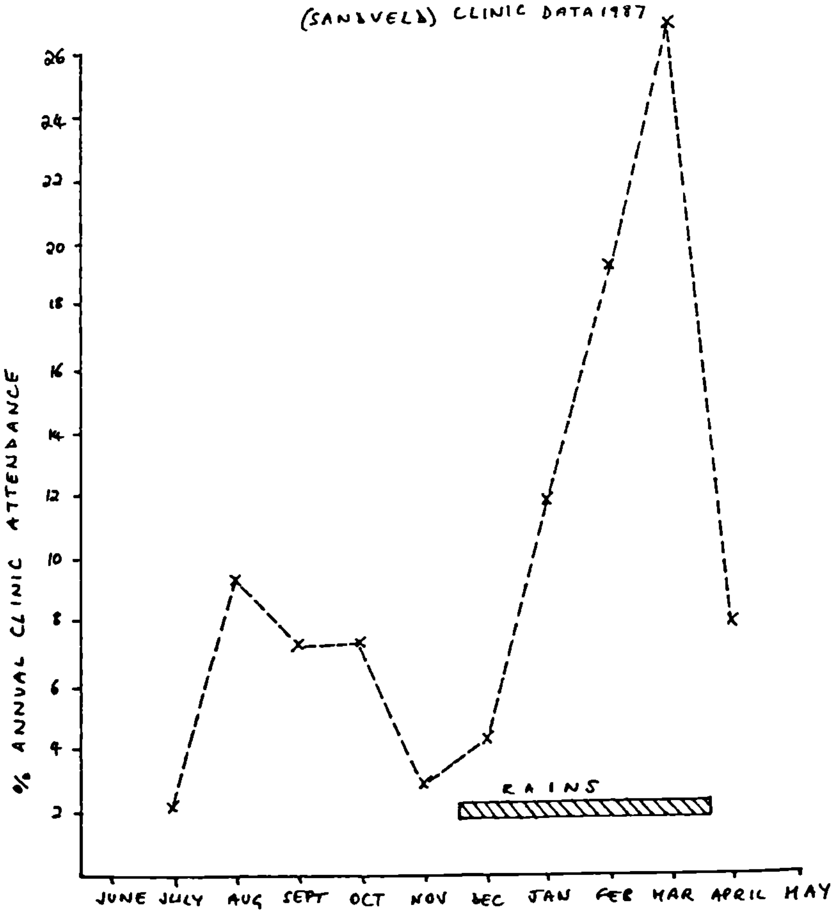


FIG 6.1.5.2 SEASONALITY OF SORE EYES: MUTAMBE (SANDVELD) CLINIC DATA 1987



Sandveld Clinic Data

Graph 6.1.4.2 shows clinic attendance with diarrhoea at Mutambe (on sandveld) for under five year olds in the calender year 1987 on sandveld. Levels appear to rise in November, immediately prior to the rains, and then remain high until after the rains ended (February in that year, 1987), and the temperature declined. This result of hot season elevation thus supports the child morbidity data obtained through recall.

Indigenous knowledge and beliefs about diarrhoeal seasonality

There are strong local beliefs/perceptions concerning the seasonality of diarrhoea. The 'shooting of new leaves by trees' is said to bring with it an increase of diarrhoea, especially for children still suckling. Leaf-burst happens in the hot dry season (September) on sandveld, whilst on clayveld it generally follows the onset of the rains proper (cf. Chapter Three). Historically, these people have settled the sandveld (Appendix Two), and it is clear that people have in mind the early shooting of the miombo flora prior to the rains when referring to the relationship between bud-burst and diarrhoea. Although I was originally convinced that diarrhoea would only increase with the rains proper, in line with the vague notions of water pollution as a cause found in the literature, data presented above show that diarrhoea did indeed become more frequent prior to the onset of rains in both the 1986-7 and 1987-8 Mototi sample data, and in the data from the Mutambe Clinic in 1987. Likewise, after the rains and into the cold dry season the level of diarrhoea apparently declines in all these data sets.

Table 6.1.4.3 presents the reported causes of diarrhoea presented in the context of questions concerning the seasonal increase in diarrhoea from a sample of 63 women interviewed in September and October 1986.

Although the belief about bud-burst is 'traditional', it is only one of a large range of ideas about diarrhoeal causation. It is clear that women conceive it as the most convincing explanation because they continue to observe the uncanny correlation between leaf-out and rising diarrhoeal levels, and not because they are unaware of other causal processes. (This relationship reflects, of course, the fact that both leaf-out and diarrhoea are dependent on the changes in the same variable, temperature.) As people cannot see how bud-burst should cause diarrhoea they go to some lengths to rationalise it, including using public health concepts derived from elsewhere (see Notes to Table 6.1.4.4). (In fact, many - if not most - government health workers also believe that leaf-out causes diarrhoea.) No "traditional" reason was given by women for tree leaves causing diarrhoea. However, some old women stated that the reason why they are said to specifically endanger suckling children is to persuade women to wean their infants immediately prior to the rains so that they can be free for agricultural work.[15] Other women did not accept this arguing that they could work adequately even when breast feeding at intervals. It is interesting that conceptualisations of the 'belief', and the way people respond to it, revolve around compromises between infant welfare and women's labour obligations. If there actually is a seasonality in weaning (not investigated) this would be expected to lead to increased diarrhoea in the time period immediately afterwards (cf. Rowland *et al.*, 1978; Tomkins, 1979; Elegble and Ojofeitimi, 1984).

Table 6.1.4.2 Causes of Diarrhoea Reported by Mothers

	% respondents *
Trees shooting new leaves:	94
Excessive heat:	41
Dirty water:	32
Babies teething:	21
Excessive consumption of leaf veg:	19
'Bad' food:	8
Early rainfall:	3
Tea consumption:	2
Flies increasing on food:	2

Notes to Table 6.1.4.2:
* As most gave more than one response the total is well over 100%

Diarrhoea associated with breast feeding infants where the mother has a new pregnancy (kumwira); extreme dehydration associated with diarrhoea and vomiting in which the fontanelle becomes depressed (nhova); diarrhoea in suckling infants caused by parental adultery; and diarrhoea resulting from the trial by ordeal of virgins suckling the child; were deliberately excluded from this survey.[16]

Some reasons given by women for the shooting of new leaves causing infant diarrhoea:
'these leaves drop worm eggs onto leaf vegetables'
'new leaves pollute drinking water by falling into wells'
'new leaves reflect bright light, which disturbs the children'
'there are some "bacteria" [Eng.] in these new leaves'

The association between leaf-out and diarrhoea (Table 6.1.4.4) is apparently culturally-rooted wider than the southern Shona (Karanga). Gelfand (1964:164) records of central Zimbabwe that *n'anga* (healers) may treat the community with a prophylactic in September. Fifteen per cent of this Mazvihwa sample of 63 mothers stated that they used prophylactic treatment against this category of diarrhoea.

In regard to 'other explanations' it is interesting that more women blamed the increase in diarrhoea on the increasing temperatures than on the rains; especially since at the time of the study I was convinced that it was the rains that were responsible.

In a further series of questions about seasonal patterns of disease and growth, answered by 47 women in this sample during the rains of 1987-8, many of the women mentioned diarrhoea associated with the harvest period. This is often called **rupwa runyoro**, in reference to its link with the consumption of fresh foods. Mothers said that in the midst of plenty children gorged themselves on maize cobs, water melons, roasted and boiled pulses, etc. and were consequently struck with diarrhoea.[17] This may be the explanation for the raised level of diarrhoea which was recorded in the harvest period after the good harvest 1987-8 year, but not seen in the poor harvest year (1986-7).

In a rapid survey of four rural areas in Zimbabwe, (Zoysa *et al.*, 1984a), many of the same diarrhoeal causal factors were reported as above, except for the shooting of new leaves by trees. In addition, large percentages of the samples in some communities reported back government health education concepts concerning flies and personal hygiene. This might have been due to direct translator-interference, or could reflect that the particular communities had been well reached by the health services and wished to demonstrate their new-found knowledge. However, Zoysa *et al.* (1984a) mistakenly report them as indigenous concepts.[18] In this study only 2% of women reported the 'flies' explanation, though most of them have been informed about it by the health services, and would discuss it when asked, pointing out the subtle differences between knowledge, belief and statement and the significance of the interview context.

6.1.5 Contrasting patterns of seasonality in "sore eyes" between zones

The limited data on ocular infections suggests a contrasting seasonality between moist and arid savannahs. McGregor *et al.* (1970:54-5) observed that skin sepsis and eye infections showed a wet season peak in the Gambia. This is probably the typical pattern in moist savannahs. However, in the semi-arid savannah of Mali, Hildebrand (1985:274-84) reported that conjunctivitis showed a pronounced dry season peak in a year-long survey, and Hildebrand *et al.* (1985:62) accounted for this by reference to: 'The dry environment and sandy winds which particularly blow in winter'. Bernus (1988:332) reports of the Sahel that the winds in the dry season bring an increase in ocular infections, and a cross-sectional survey in the hot dry season in Mali (Chabasse *et al.* 1985:331) did report very high levels of eye infections (24% of people examined had ocular lesions).[15] These differences between arid and moist savannahs probably reflect factors of hygiene and dust (see Section 6.1.1). It is therefore possible to predict that the clayveld will show the 'arid' pattern, with a dry season peak, and the sandveld the 'moist' savannah pattern, with a wet season peak. Table 6.1.5.1 presents the "sore eyes" seasonality data for the Mazvihwa study.

Table 6.1.5.1 Sore Eyes Seasonality in 1986-8

	Sandveld 1			Sandveld 2			Boundary			Clayveld		
	N Ill	N Samp	%	N Ill	N Samp	%	N Ill	N Samp	%	N Ill	N Samp	%
Cold Dry	2	46	4.3				4	87	4.6	18	131	13.7
Hot Dry	1	50	2.0				5	143	3.5	11	178	6.2
Rains	7	99	7.1	10	169	5.9	14	229	6.1	7	313	2.2
Harvest	7	63	11.1				10	104	9.6	9	196	4.6

Notes to Table 6.1.5.1:
Figures are percentage of children ill with sore eyes in the 'past week' at each time of questioning
Cold dry season refers to July/Aug in 1986 and 1988
Hot dry season refers to Sept/Oct 1986 and Nov/Dec 1987 (rains started later in the latter year)
Rains refers to Nov/Dec and Jan/Feb 1986-7 and Jan/Feb 1988
Harvest refers to Mar/Apr in 1987 and Apr/May 1988
Sandveld 1 is the normal Mototi sandveld sample
Sandveld 2 is a one-off survey in an adjacent Mutambe Ward Vidco in Feb 1988

Statistical analysis
Clayveld sore eyes morbidity is higher in the dry season than the wet, 9.4% versus 4.6%, χ^2 1df., 3.89 p<0.05

Sandveld sore eyes morbidity is higher in the wet season than the dry, 11.1% versus 3.1%, χ^2 1df., 4.17 p<0.05; but note that one 'expected' value is less than the required 5, at 3.96)

Wet season sandveld versus clayveld: Combined wet season 1986-7 (Nov/Dec plus Jan/Feb) plus wet season 1987-8 (Jan/Feb): Mototi sandveld and the single record for Mutambe sandveld (from Feb 1988) pooled; contrasted with the Mototi clayveld. Sandveld infection stands at 6.3% versus clayveld at 2.2%, χ^2 1df., 6.2, p<0.02.

Post-harvest period: Mar/Apr 1987 combined with Apr/May 1988; Mototi sandveld versus clayveld: 11.1% versus 4.6%, χ^2 1df., 3.49, p<0.1 n.s. (note, too, that one 'expected value' in the χ^2 is 3.9).

Dry season sandveld versus clayveld: Combined dry season levels from Jul/Aug and Sept/Oct 1986, Nov/Dec 1987, and July/Aug 1988; Mototi sandveld versus clayveld: 3.1% versus 9.4% respectively, χ^2 1df., 3.8, p<0.05.

"Sore eyes" morbidity shows a very marked reverse seasonality between the sandveld and clayveld. In clayveld sore eyes is more common in the dry season than the rainy season, and in sandveld it is more common in the rainy season than dry season. The higher rate in the wet season in sandveld is carried over into the harvest season, but is no longer statistically significantly higher than clayveld. The boundary population shows an ameliorated seasonality regime throughout.

Attendance with sore eyes at a sandveld clinic (Mutambe) also shows a rise in eye problems in the rainy season during 1987; see Graph 6.1.5.2 (page 214). No comparable data is available for a clayveld clinic.

6.1.6 Contrasting seasonality of ear, nose and throat infections

Moist and semi-arid savannahs also appear to show seasonal contrasts in ear, nose and throat (ENT) and respiratory infections. Rainy-season peaks in respiratory infections were observed in moist savannah in the Gambia (McGregor *et al.*, 1970:53), except for whooping cough. (That study did not record minor infections such as colds and runny noses.) The authors related higher wet season morbidity to the crowded, smoky, conditions inside huts during this time of year (1970:68). The rainy season was also the time of elevated respiratory infection in Trinidad, whilst in Sheffield, UK, the winter showed highest levels (Sutton, 1965). Sutton (1981:112-3) later concluded that the effect of rainfall and cold in the two respective areas was to lead to crowding and hence greater transmission (see also Bradley 1981:130). In the equational climate of Bagamoyo, Tanzania, there was little lower respiratory tract infection seasonality in hospital admissions, but there was a peak at the start of the long rains (Goetz, 1981:183-4).

In contrast Hildebrand (1985:274-281) reports that respiratory infections peak in the cold dry season in semi-arid Mali: and this may be the general pattern in the Sahel (Bernus, 1988:332) and Northern Nigeria (Tomkins, 1981: 177-8).[20] In the Indian sub-continent the cold season is the time of peak mortality from respiratory infection (eg Chen *et al.*, 1980b:30). This is also the broad pattern seen in this study in Zimbabwe, and is what is stated by most local people interviewed to be the typical pattern in this area. The difference between the wet season Sudan and Guinea-savannah peaks on the one hand and the Sahel and arid southern Africa dry season peak on the other, is probably largely the greater distance from the equator and the effect that this has on the annual temperature variations. The winter is cold in these drier areas, and frost is not unknown, and winds can also be strong. In addition to the drop in temperature in the dry season due to latitude, the low amount of rain in the rainy season means that the temperatures during the time of maximum insolation are little ameliorated and so tend to be higher in the rains in the drier areas, rather than falling as they often can in the wetter areas. Furthermore, there is more dry-season dust in the drier areas than in the moist savannahs, and this may also raise ENT levels.

The fact that rainfall and latitude are similar between the sandveld and clayveld in this study area means that the temperature effect can not be expected to cause differences in seasonality between zones. However, there are other factors that differentially affect infection between the ecological zones. In particular the considerable amount of fine dust in the clayveld during the dry season (see Chapter Three) may increase infection in this zone at that time. Nutritional status and general physiological stress, may affect vulnerability to infection, or, more likely, may slow recovery, and the times of stress occur at opposite times in the two zones (Chapter Five and Section 6.1).

Graph 6.1.6.1 of ENT infections for the period 1986-7 shows that wet season sandveld levels are higher than wet season clayveld levels as expected; in the dry season the levels are not statistically significantly different. Within clayveld the rates are higher in the dry season than the wet season as expected. Boundary populations show the predicted intermediate levels between sandveld and clayveld.

Statistical analysis of differences between zones and seasons in 1986-7
This analysis is based on the figures used to construct Graph 6.1.6.1.

Sandveld wet season (Nov/Dec and Jan/Feb) rates are higher than wet season clayveld (38.5% versus 14.2%); this is statistically significant (χ^2 1df., 18.3, $p<0.001$).

During the dry season (Jul/Aug and Sep/Oct) sandveld rates are still higher than clayveld (38.1% versus 23.8%), but not statistically significantly so (χ^2 1df., 1.84, $p<0.2$).

Whilst sandveld rates in the wet and dry season are similar, clayveld dry season rates are higher than clayveld wet season rates (23.8% versus 14.2%), and this is statistically significant (χ^2 1df., 5.0, $p<0.05$).

The prediction that in the wet season the level of ENT and chest infection in sandveld will be higher than that in clayveld is supported in 1987-8 as it was in 1986-7 (Graph 6.1.6.1). However, in 1987-8 there is no overall difference between sandveld and clayveld infection in the dry season when it was predicted that clayveld infection rates would be higher. From the hot dry season to the rains the sandveld rates increased as predicted whilst clayveld rates stayed similar, but this was not statistically significant.

FIG 6.1.6.1 SEASONALITY OF COUGHS, CHEST INFECTIONS AND 'FLUS 1986/7.

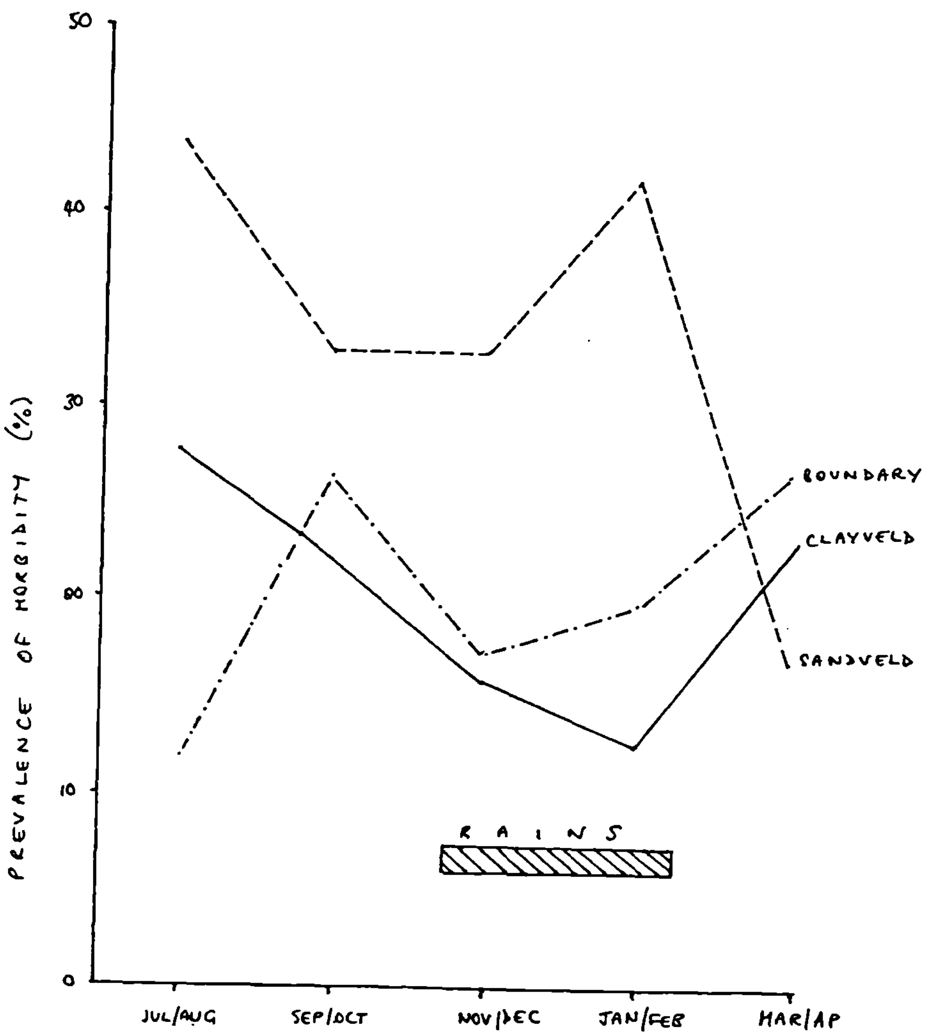


Table 6,1,6,2 Coughs, Chest Infections, Ear Infections and 'Flus in 1987-8

	Sandveld 1			Sandveld 2			Boundary			Clayveld		
	N Inf.	N Samp	% Inf.	N Inf.	N Samp	% Inf.	N Inf.	N Samp	% Inf.	N Inf.	N Samp	% Inf
Hot Dry	3	38	7,9				6	79	7,6	8	80	10,0
Rains	6	34	17,6	30	169	17,8	8	79	10,1	13	109	11,9
Harvest	1	28	3,6				5	63	7,9	2	108	1,9
Cold dry	13	37	35,1				29	53	54,7	21	99	21,2

Notes to Table 6,1,6,2:
Hot dry season in 1987-8 data refers to Nov/Dec 1987
Rains in 1987-8 data refers to Jan/Feb 1988
Harvest in 1987-8 is Apr/May 1988
Cold dry season in 1987-8 data refers to July/Aug 1988
Sandveld 1 is the normal Mototi sandveld sample
Sandveld 2 is a one-off survey in an adjacent Vidco in Mutambe Ward

Statistical analysis:
Wet season sandveld versus clayveld: Mototi and Mutambe sandveld pooled versus Mototi clayveld; 17,7% versus 11,9%, χ^2 1df., 1,8, p<0,2 n.s.

Hot dry season levels show predicted higher clayveld levels: but this is not statistically significant.

Cold dry season levels show the opposite pattern to that predicted, but this is not statistically significant, χ^2 1df., 2,79, p<0,1.

Sandveld in wet and dry seasons: Mototi sandveld rates increase in the rainy season in 1988 from the hot dry season of 1987, but this is not statistically significant, χ^2 1df., 1,55, p<0,3. (Much higher levels are then reached in the cold dry season following: this is discussed in Section 6,2,3.)

Clayveld in wet and dry seasons: marginal increase in wet season from 1987 (opposite to predicted, but not stat. sig.); but a major increase from rains to dry season 1988 (as predicted), see Section 6,2,3

There is further discussion of these data in Section 6.2.3 in reference to the differences in ENT levels between years. In particular the increase of infection in the cold dry season in 1988 is examined.

The data on ENT infections suggest that there is a small difference in seasonality between the sandveld and clayveld zones. It is in the wet season that marked differences in infection levels are observed, with the sandveld experiencing higher morbidity as expected.

6.1.7 Contrasting seasonality in measles infection

In regard to Zimbabwe, Waterston and Nhembe (1984:99) remark that: 'measles incidence is normally highest in June to October' (the dry season) and are presumably referring to hospital admissions in the highveld. However, Sutton (1981:114) records that a peak in measles is seen in November to January (wet season) in Zimbabwe, Malawi and Zambia; and Goetz (1981:184) showed that measlkes was most frequent in the short rains in the moist savannah of Tanzania. Sutton (1981) contrasts this with dry season peaks in West Africa (cf. Aaby *et al.* 1984 for moist savannah/forest boundary; de

Waal, 1989a:19, for Western Sudan; Tomkins, 1981:178 for Zaria, Northern Nigeria; and Tomkins (1986:296) for a general statement on dry season measles in savannah Africa due to favoured conditions for nasopharyngeal colonisation. Chen *et al.* 1980b:29-30, note dry seasonal increases in measles in South Asia); and an April peak in bimodal rainfall East Africa (Sutton, 1981:114). Neither Waterston and Nhembe or Sutton adequately define the areas they are referring to or the source of their data. In my own study there is also some uncertainty about the timing of peak measles infection, though there was some support for an opposite seasonality pattern.

The four clayveld children who suffered from measles during the prospective health monitoring all contracted it during the dry season. Yet in the clinic data from sandveld clinics Mutambe and Murowa (1987), 17 out of the 18 cases of measles treated were in the rainy season (Jan/Feb/Mar). (No clayveld clinic data is available). Questions on measles seasonality to 62 mothers from sandveld, boundary and clayveld populations were undertaken in 1988, but there was some confusion about the translation of measles into indigenous terms - including perhaps over measles and German measles - as I was not present.) All population samples identified the hot summer dry season as the worse time for measles, though there was indeed a greater proportion of clayveld mothers stating that the predicted dry winter season was the time of peak infection in their zone. This was also what was recorded in the in-depth interviews conducted with clayveld and boundary population women in 1985 and 1986 with a medical student, A. Irene Masanga. Therefore it is not possible to be certain that the wet season bias in sandveld clinic attendance reflects the typical situation. However, it is possible that on clayveld there is a more dry season peak, whilst on sandveld the peak is in the rainy season. This would suggest that there is a reversal in measles epidemiology depending on ecological conditions, but the aetiological basis for this remains elusive.

6.1.8 Conclusions to Section 6.1

Section 6.1 has drawn attention for the first time to the fact that differences in the ecology of semi-arid and moist savannahs mean contrasting seasonality patterns. Though these differences partly reflect the general climatic differences between the environments on a regional scale (rainfall and especially temperature), through the Mazvihwa case study I have been able to show that even where there are no climatic differences contrasting seasonalities can result from purely ecological differences alone as a function of soils, moisture, and vegetation relations. However, the influence of ecological dynamics is not sufficient to influence gastro-enteritis seasonality. Indeed this study suggests that far too much attention to water supplies and environment has been given to investigation of diarrhoeal seasonality, and that temperature effects on food contamination rates are more significant (see also Section 6.3). Other morbidity does tend to follow a seasonal contrast between the zones, however, though the causal basis of this is not always apparent.

6.2 Inter-annual variation in morbidity

6.2.1 Introduction: a review of existing data and hypotheses about inter-annual variation in morbidity with rainfall

This discussion seeks to establish how high and low rainfall affect morbidity in savannah environments. This discussion is used to hypothesise that drought will tend to elevate morbidity in semi-arid savannah types (and hence clayveld in Mazvihwa), whilst it is high rainfall that raises morbidity in moist savannahs (and hence sandveld in Mazvihwa.)

Systematic longitudinal monitoring of rural African children to examine inter-annual variations in morbidity have only been conducted in the MRC study in the Gambia and the Dutch/Kenyan study of Machakos. Neither study explicitly examined their data for the effects of inter-annual rainfall variations. The Kenyan study found no differences in diarrhoea levels over four rainy seasons (two years) (Leeuwenburg *et al.* 1984a:114), and do not report the effects of rainfall on any other ailment. Measles (Leeuwenburg *et al.* 1984b:82-3) and pertussis (Muller *et al.* 1984:99-100) show periodic recurrence of two and three years respectively, presumably in response to 'herd-immunity' factors, a common phenomenon in Africa and elsewhere. The Gambian study has not explored data to look at inter-annual variation in morbidity. However, particularly notable growth faltering in one year was believed linked to exceptional morbidity due to high rainfall in that year (McGregor *et al.* 1970:57), and a dry series of years (the Sahel drought) appears to have lowered endemic communicable disease levels between 1971 and 1975 (Billewicz and McGregor 1981:225). High rainfall can indeed be expected to worsen the disease environment.

Despite a popular literature to the contrary there is no hard data suggesting that the major recent African droughts have in themselves been associated with higher morbidity. Indeed, Seaman *et al.* (1973:776) report that in the very severe drought of 1973 the Sahel that morbidity levels were 'normal' in the areas visited. The measles epidemics early in the drought were neither caused by the drought, nor their effects worsened by the drought. The cholera outbreaks showed an obscure relation to the drought, if any at all (Seaman *et al*, 1973:776). The Centers for Disease Control Annual Report at the time notes of malaria, diarrhoea, meningitis, and tuberculosis etc., that: 'none of these diseases appear to have significantly increased in incidence during the past year' (Sheets and Morris, 1974:133). As pointed out by Seaman and Holt (1980:294) increased exposure to morbidity becomes a factor amongst the drought/famine displaced (cf. Pankhurst, 1985; Rangasami, 1988) who then congregate in huge numbers around available food and/or water. Severe morbidity and mortality tends to occur in such groups (Seaman *et al.* 1978:35-7; D'Souza, 1988:32-7; Shepherd, 1988:31 ; and de Waal 1989 a & b). In Southern Zimbabwe none of the historical famines have led to large scale population displacement (except for Ndanga in 1917: Iliffe, 1990:66).[21] However,there is typically increased movement of individuals for trade, and movements (mainly of children) to live with 'relatives' in less affected rural areas or towns. Note that in Chapter Four household demographic data is presented indicating that the drought of 1987 led to a fall in population in the clayveld zone due to out-migration of this type. One reason for little migration is the resilience of water supplies reflecting shallow granite base rock (sandveld), riverine settlement (clayveld) and Government dam and borehole programmes (which are preferentially sited where the Government has forced people to live away from natural water supplies).[22]

Mission Clinic[23] observations in the study district from the 1920s-1940s in an area marginal between sandveld and clayveld record exceptional morbidity in two wet years, and less malaria resulting in lower morbidity in dry years. This is further support for the notion that in fact morbidity in savannah environments can often be worse in wet years than dry years. However, two severe drought years at this time also showed elevated morbidity, and observed high morbidity in some further years was not readily explained by the mission staff. It might be that both exceptionally wet and dry years can lead to elevated morbidity, or the result could reflect the fact that the area is one of intermediate soils/ecology. Donaldson (1984:199) reported exceptional clinic attendance in the dry season of the drought year 1960 in the clayveld of the Sabi valley in Zimbabwe. This gives support to the hypothesis that it is clayveld that will be particularly affected by elevated morbidity in droughts.

The literature reviewed above suggests that both lower and higher rainfall can potentially worsen disease-environment, but that lack of data means that specific relationships are still open for speculation. I propose a general hypothesis that it is in the moist savannahs that disease-environment is worsened by elevated rainfall, and in the dry savannahs that it is made worse by low rainfall. These effects could be marked in the wet and dry seasons respectively. The reasons for this are an extension of the arguments reviewed in 6.1 when discussing the seasonal disease environments in these two zones, and reflect the behaviour of sandveld swamps and clayveld dust and lack of plant cover under varying rainfall (Chapter Three).

Variations in rainfall can affect morbidity not only through disease-environment but also through nutritional decline increasing susceptibility (where this is sufficiently serious, Martorell and Ho, 1984; see literature review and examination of data for this sample population, Section 6.4).

6.2.2 Changes in Overall Morbidity

Analysis can be made of morbidity levels from 1986-8 to consider the effects of rainfall variability. The first year (1986-7) followed a relative harvest failure (in the 1985-6 season), in a year that was itself very low rainfall Then Nov/Dec 1987 and Jan/Feb 1988 correspond to the end of the 'famine' which followed a second and more marked harvest failure (1986-7). The subsequent period, Apr/May and Jul/Aug 1988, cover the harvest period in a year of adequate crop, and the dry season immediately afterwards.

Thus the data available for 1986-7 and the first part of the 1987-8 data can be used to compare morbidity under different degrees of economic deprivation in a single 'drought' period of several years' length. Interpretation is complicated by the fact that within this 'hunger' period heavy rains fell in the 1987-8 season, preceding a good harvest being reaped. Differences in rainfall-dependent 'disease environments' may therefore also play a role in differences between the years, at least in regard to the Jan/Feb 1988 data.

The data for the second part of 1987-8, that for the post-harvest period and cold dry season in a year of good harvest, can be contrasted with the morbidity levels during the same seasons in drought years.

There are large differences between ecological zones in levels of morbidity between seasons and years as the drought progresses (Table 6.2.2.1). Though the changes are marked they are not very consistent or easy to interpret.

Table 6,2,2,1 Inter-Annual Changes in Morbidity Rates for 1986-8

		MID DROUGHT Morbidity in 86-7		PEAK DROUGHT Morbidity in 87-8		AFTER HARVEST Morbidity 1988	
		N sample	% ill	N sample	% ill	N sample	% ill
SAND	Dry season	21	42,9	38	28,9	37	59,5
	Wet season	65	55,4	34	32,4		
	Harvest	35	31,5			28	25,0
BOUND	Dry season	98	45,9	79	25,3	53	66,4
	Wet season	150	39,3	79	46,8		
	Harvest	41	53,7			63	36,5
CLAY	Dry season	130	56,2	80	31,3	99	52,5
	Wet season	204	36,3	109	45,9		
	Harvest	88	35,2			108	27,9

Notes to Table 6,2,2,1;

Total observations 1639,

Dry season is Jul/Aug and Sept/Oct in 1986; Nov/Dec in 1987-8; and Jul/Aug in 1988
Wet season is Nov/Dec and Jan/Feb in 1986-7 and Jan/Feb in 1988
Harvest is Mar/Apr in 1987 and Apr/May in 1988

Statistical analysis

Comparing seasons in different years
Dry seasons; (zones pooled)
1986-7 versus 1987-8; 51% versus 28%, χ^2, 1df, 23,1, p<0,001 (Morbidity falls as drought worsens)
1987-8 versus 1988; 28% versus 58%, χ^2, 1df, 33,7, p<0,001 (Morbidity rises as drought ends)
1986-7 versus 1988; 51% versus 58%, χ^2, 1df, 1,9, p<0,2 n,s, (No diff in morb before+after drought)

Wet seasons;
Clayveld plus Boundary
1986-7 versus 1987-8; 38% versus 46%, χ^2, 1df, 3,9, p<0,05 (Morbidity rises as drought worsens)
Sandveld;
1986-7 versus 1987-8; 55,4% versus 32,4%, χ^2, 1df, 4,7, p<0,05 (Morbidity falls as drought worsens)

Post-Harvest;(zones pooled)
1986-7 versus 1988; 39% versus 30%, χ^2, 1df, 3,2, p<0,1 n,s, (No diff in morb before+after drought)

Monitoring morbidity as the drought progresses;

Dry season 1987 versus rains 1988; (zones pooled)
28% versus 44%, χ^2, 1df, 11,1, p<0,001 (Morbidity rises as drought progresses)
Rains 1988 versus post-harvest 1988; (zones pooled)
44% versus 30%, χ^2, 1df, 8,8, p<0,01 (Morbidity falls as harvest made)
Post-harvest 1988 versus dry season 1988; (zones pooled)
30% versus 58%, χ^2, 1df, 33,4, p<0,001 (Morbidity rises after good harvest)

Data in Table 6.2.2.1 show that morbidity rates during the first stage of the drought fall in all three populations, so that the period of most intense livelihood distress (the hot dry season in 1987) was actually the period of lowest reported morbidity in all three populations. This is quite surprising, and was predicted only for sandveld. Subsequently, there is evidence for rising morbidity in the wet season at the end of the drought (the time of peak cereal shortage), especially in the more drought vulnerable clayveld and boundary populations (as had been predicted). There is an improvement in all three populations with the harvest that breaks the drought; it had been predicted that any improvement in sandveld would be less than in the other two zones. However, there is then a peculiar marked increase in morbidity in the dry season after this harvest in all three populations. This anomalous overall change in morbidity is actually only a function of oscillations in ear, nose and throat (ENT) infections (see Sections 6.23 and 6.2.4)

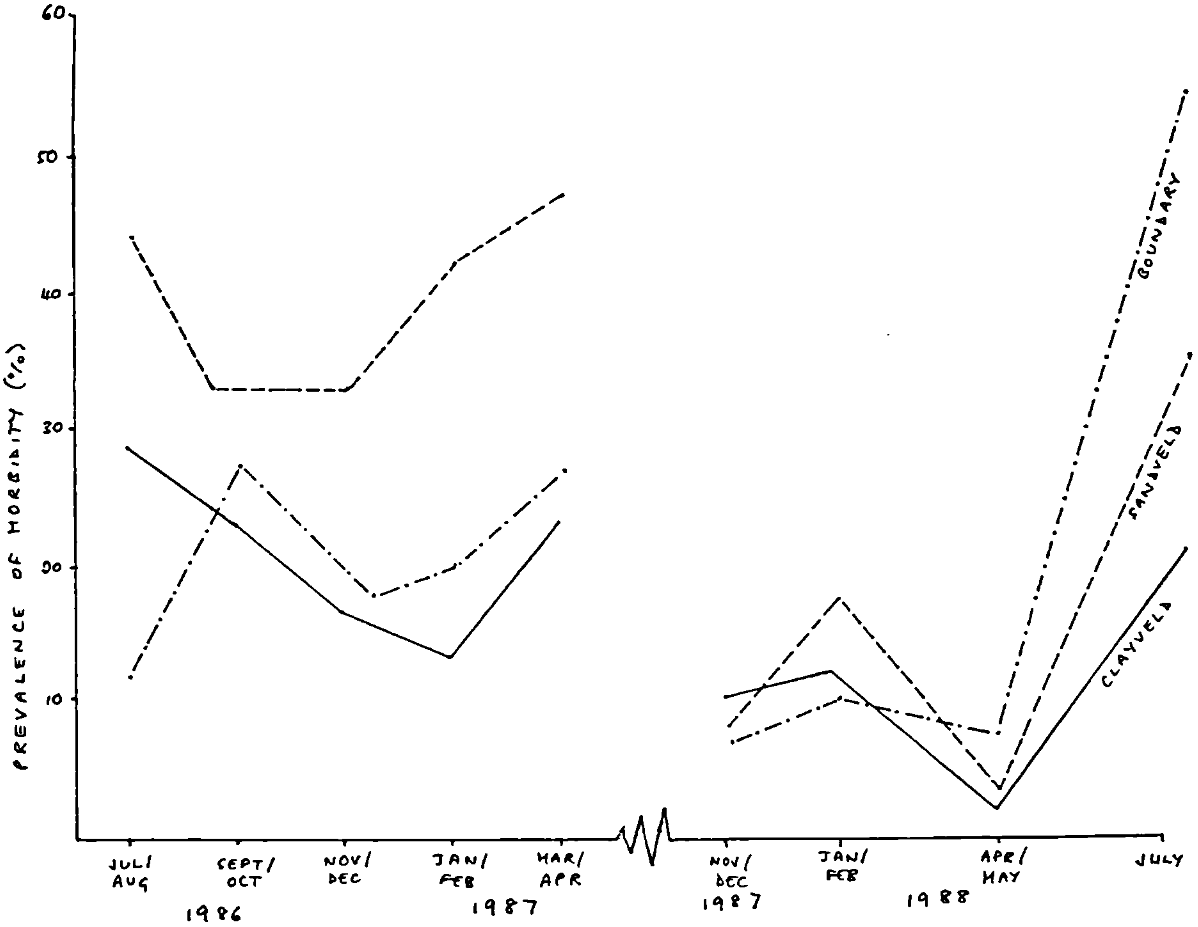
6.2.3 Inter-annual variations in Coughs, Chest Infections, Ear Infections and 'Flus (ENT)

Graph 6.2.3.1 shows changes in the frequency of coughs, 'flus, chest and ear (ENT) infections over the two year period.

There may be three periods of different levels of infection. During 1986-7 (zones pooled) the level is about 20%, whilst between Nov/Dec 1987 and Apr/May 1988 it was only 8%, (χ^2, 1df. 38.1, $p<0.001$). After this period of low ENT morbidity there is another peak in Jul/Aug 1988 when it stands at 33% (zones pooled). This is much higher than the low rates earlier in 1987-8, (χ^2, 1df. 73.6, $p<0.001$). An alternative division of the period would be into peaks in both cold dry seasons (Jul/Aug), and then contrasting ENT morbidity levels in the September-April period in the two years in question.

This overall pattern means, therefore, a decline in ENT infections during the drought period under study. Whether such a decline in ENT is typical of droughts is unknown, but does appear surprising as increased susceptibility (due to physiological stress) and exposure (due to greater rural-urban and rural-rural migration) could be expected, especially in clayveld. The disease-environment effect of dryness is also not the explanation as ENT morbidity levels remain low even through the exceptional rains of the wet season in 1987-8. Furthermore dryness seems more likely to increase ENT infections than decrease them (see Sections 6.1.1 and 6.1.6).

FIG 6.2.3.1 INTER-ANNUAL VARIATION IN CHEST AND EAR, NOSE AND THROAT INFECTIONS, 1986-1988



It is probable that the fluctuations in ENT infection levels occur independently of rainfall variation. This is supported by the fact that there is correlation between the levels of infection in all three zones through time. The factors responsible for these fluctuations have not been identified, but two possibilities are irregular 'epidemics' and systematic observer bias.

6.2.4 Residual inter-annual variation in morbidity without ENT infections

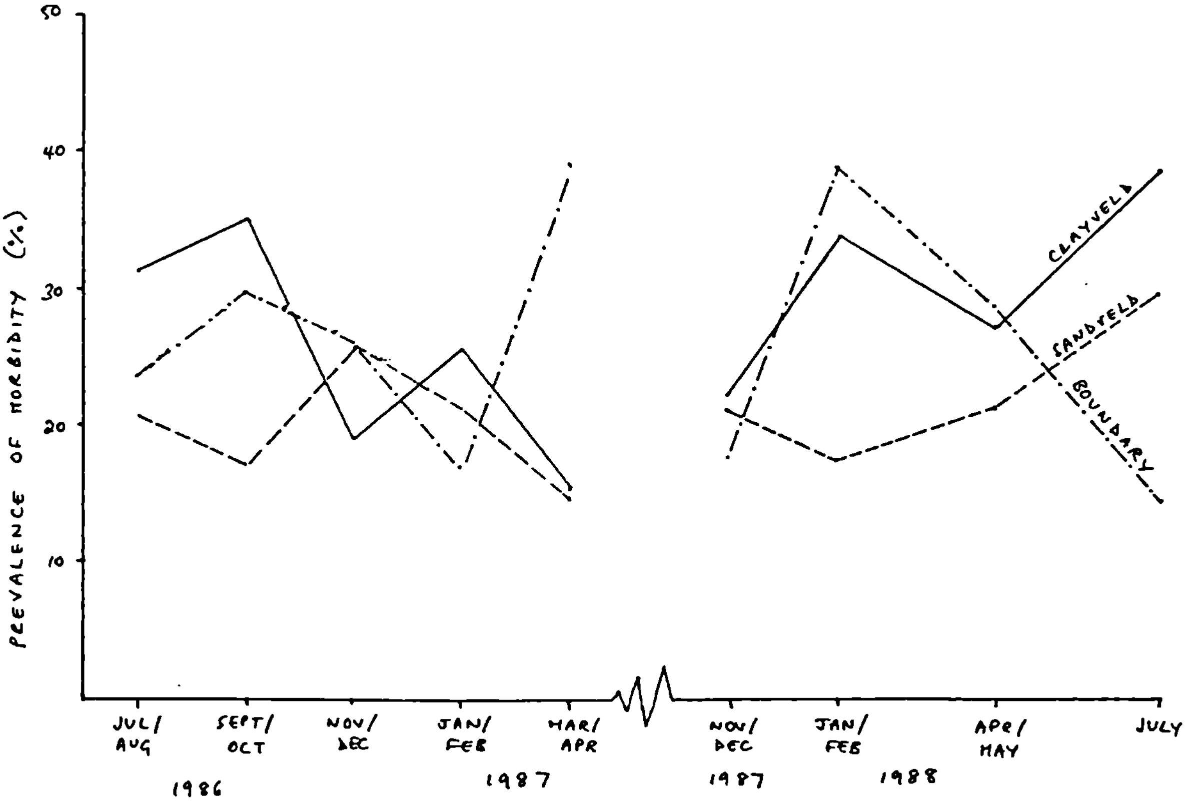
This section analyzes the variations in overall morbidity without coughs, 'flus, chest and ear (ENT) infections (see Graph 6.2.4.1). ENT infections are shown in 6.2.3 above to vary apparently independently of inter-annual rainfall variation, and may therefore be obscuring underlying patterns of overall morbidity variation due to drought.

Graph 6.2.4.1 suggests that in fact much of the differences in general and overall morbidity between zones at any one point in time, and of the differences in levels of morbidity through 1986-8 (Section 6.2.2), are actually a function of changes in prevalence of the ENT group of related symptoms. Indeed, it is actually a decline in ENT infection during the hot dry season 'peak' drought period that is responsible for the lower overall morbidity at this time, which was otherwise difficult to explain, especially in clayveld (6.2.2).

It is now possible to test the original prediction that drought would elevate clayveld morbidity more than that of sandveld and boundary populations, excluding the contribution of ENT infections. This prediction is to some extent supported by the data, as detailed below.

Comparisons of overall sandveld and boundary population morbidity levels in 1986-7 with 1987-8 (excluding ENT infections) suggests that there is no overall difference in morbidity levels. (Except for the wet season rate in the boundary sample which is statistically significantly higher in 1987-8 than 1986-7; χ^2, 1df. 8.3, $p<0.01$.) That is the hypothesis that drought does not increase morbidity in these ecological zones is confirmed.

FIG 6.2. .1 INTER ANNUAL VARIATION IN MORBIDITY, WITHOUT CHEST AND EARS, NOSE + THROAT INFECTIONS, 1986 – 1988



The clayveld figures (without ENT), in contrast, support the prediction that morbidity rates are raised in this population by drought-induced stress. Without ENT the hot dry season morbidity in the 1987-8 drought is no longer statistically significantly lower (Section 6.2.2) than the hot dry season in 1986-7 (during a less severe stage of the drought). Wet season combined with the harvest season clayveld morbidity in 1987-8 now show notably higher morbidity than they did in 1986-7 (31% versus 21%, χ^2, 1df. 7.6, $p<0.01$), suggesting that morbidity was driven up at the end of the drought. This would be expected to happen in clayveld because of the stress induced by the previous drought, and in sandveld as a result of the high rainfall wet season. Finally, without ENT, the cold dry season after the good harvest of 1988 shows a similar rate to the cold dry season in 1986-7, overcoming the anonomaly of morbidity being elevated in the dry season after a good harvest (Section 6.2.2).

This section thus establishes that underlying any changes in ENT infections there may indeed be a greater clayveld vulnerability to elevated morbidity following droughts.

6.2.5 Conclusion to Section 6.2

Drought was predicted to show greater negative impact on levels of child morbidity in the clayveld environment than in sandveld and boundary populations. However, changes in overall morbidity were not readily interpretable as parts of the periods of dearth showed elevated morbidity, whilst others depressed levels. It was found that considerable fluctuations occurred in ear, nose and throat (ENT) infections, apparently unrelated to rainfall, and perhaps reflecting irregular epidemics. Once the contribution of these ENT infections was removed, the changing levels of morbidity through time became clearer. Indeed, there was then broad support for the hypothesis that morbidity levels would be elevated by low rainfall only in drought-vulnerable clayveld. In contrast, morbidity levels in sandveld and boundary remained steady under drought. However, it had been suspected that there might even be a decline in morbidity with drought in sandveld, but this was not observed in the year in question. Clearly much more data for drought, average and high rainfall years would be required for adequate investigation of this phenomenon.

6.3 Effect of water supplies, sanitation and cleanliness on health, nutrition and mortality

Introduction

Domestic water use and sanitation are often considered to make an impact upon health and well being. Section 6.3.1 explores the considerable differences in water source between ecological zones, 6.3.2 examines whether water use level differentials have an impact on health and welfare, whether borehole water use improves welfare status is tested in 6.3.3. The impact of pit latrine use is explored in Section 6.3.4, and finally, the effect of household cleanliness (yard sweeping) is considered in Section 6.3.5.

6.3.1 Contrasts in water supplies between ecological zones

Table 6.3.1.1 Sources of domestic water supply in 1986-7[1]

	Sandveld n kitchens=11		Boundary n kitchens=28		Clayveld n kitchens=45	
	n using	% using	n using	% using	n using	% using
Hole in sand of river or stream[2]	0	0	28	100	37	80
Well in dambo[3]	11	100	1	5[4]	0	0
Dam[5]	0	0	2	10	7	15
Borehole	0	0	0	0	10	22
TOTAL[6]	11	100	31	111	54	116

Notes to Table 6.3.1.1

1. The Zvishavane Water Project was set up by the research team during 1986-7 and is co-ordinated by Mr Z. Phiri Maseko, for which Oxfam (UK) provided much of the funding. During 1987-9 it enabled many of the homes to upgrade their water supplies with protected wells, and also build themselves a number of dams, in a joint exercise with the District Development Fund and the Government food-for-work/public works programme.

2. These pits dug in the sand (mifuku) fill with water that has seeped through the sand, and so tends to be low in suspended matter, except after floods. However, it is presumably highly contaminated with microbial fauna. Before collecting people usually remove the water and scrape clean the existing sand. This is to avoid the strong smell of goats (especially males) that may have drunk at the site, as well as provide for generally better hygiene.

3. These wells (matsime) were all open pits, except for one which was fitted with a bore-hole style pump prior to the completion of the well projects (see Table Note 1) in 1987 onwards.

4. More well use has been made in the past in this zone, and the well-upgrading being done today is facilitating further use of wells to that achieved at the start of the field study. The time of study was also one when ground water levels were particularly low due to drought.

5. The dams in question were mainly built under food-for-work labour in the 1960 'famine'. Dam water is used for subsidiary (non-consumptive) uses, except in two of the boundary households during the dry season. Where dam water is used domestically ash (or even cement powder) can be applied to settle the suspended solids prior to drinking.

6 Note that as multiple use of water supplies is possible the totals can add up to more than 100%

Water supplies in the different zones reflect the differences in ground water behaviour in the soil types described in Chapter Three (Section 3.3.1). Sandveld water supplies are derived from shallow wells in dambos, whilst those on clayveld are mainly riverine in origin. Water supply problems in the clayveld zone have led to the construction of some small dams (designed to catch the high surface run-off) and borehole sinkage.

Table 6.3.1.2 Daily levels of water use

	Sandveld n kitchens=11 n persons=73		Boundary n kitchens=28 n persons=155		Clayveld n kitchens=45 n persons=252	
Water used to:	litres/ kitchen	litres/ person	litres/ kitchen	litres/ person	lit/ kitch	lit/ person
Cook + Drink	32.0	4.4	19.1	3.0	25.9	4.1
Wash Utensils etc	25.2	3.5	13.9	2.1	21.1	3.3
Wash Hands + Body	32.0	4.4	18.0	2.8	23.9	3.8

Notes to Table 6.3.1.2:
These estimates were made in standard 18 litre buckets by the women in charge of that kitchen through systematic and careful interview. The rates are much higher than those found in the other study in Southern Africa (18/litres/household/day by Quin, 1959:134, for the Pedi in South Africa).

Persons per kitchen were defined as people classified as 'present' and attached to those kitchens. People 'shared' between more than one kitchen (mainly senior men) were divided equally.

Cooking and drinking were defined in the question by the terms kubika and kunwa (direct consumption). Washing utensils and other household items is referred to as kusuka (domestic hygiene). Washing the hands and body is termed kugeza (personal hygiene).

Table 6.3.1.3 Seasonal changes in amount of water used

	LEVEL OF WATER USE IN THE DRY SEASON V. THE RAINS		
	Water Use Unchanged	Water Use Increased	Water Use Decreased
Dist to source incr	10	2	14
Distance unchanged	47	4	3

Notes to Table 6.3.1.3:
The figures refer to the number of kitchens in each category of changing levels of water use

Where distance to water supply increased in the dry season there is a greater likelihood of decreased water use, compared to similar or increased water use, (χ^2 (1df) = 24.5, p<0.001).

Two of the four sandveld kitchens for which there was data changed water point, 4 of the 11 boundary kitchens, and 8 of the 27 clayveld kitchens. This suggests that there is equal likelihood of seasonal change of supply between ecological zones, at least in a fairly dry year like 1986.

In all three zones water use is divided approximately equally between direct consumption, personal hygiene and domestic hygiene, though the latter uses a little less than the first two. Sandveld and clayveld kitchens use similar amounts of water per person, but the boundary population uses one quarter to one third less water. The reason for this is not known, though it may be related to the long distance to water in many of the household clusters in that zone. The distance was greater during the 1986-7 period because there are few well developed dambos close by, and the river Runde and associated large streams, which supply the clayveld, are further away. Furthermore, many of the ancient wells in this zone had fallen into disrepair, due to intra-lineage and gender conflict, though this was partly rectified by Zvishavane Water Projects (an indigenous NGO set up alongside this research project, and run by Z. Phiri-Maseko). Lower water use in the boundary population was not directly reflected in overall morbidity and anthropometric status, however, despite the fact that during the 1987 drought the shortage of water for some of these households became so serious that the women were rising several hours before dawn to catch the nocturnal water table rise, and to outcompete other womens' water collection.

During the dry season of 1986 around thirty per cent of the water points in use in the rainy season dried up. This failure occurred equally frequently in all three ecological zones in this year. When women are forced to use a more distant water supply about half of them decrease the amount of water they use at home. (To some extent this is compensated by greater bathing and washing at the water point.) There is no evidence for enhanced seasonality of water supply in clayveld in this year.

6.3.2 The impact of water-use levels upon morbidity and anthropometric status

This section contrasts the welfare status of children belonging to kitchens which have above and below average water use per person present (9 litres/day). Households classified as wealth ranks one and two were more frequently high users and poorer categories low users of water. (Mazvihwa sample as a whole: wealth categories 1-4 separate $\chi^2 = 10.3$, 3df, $p<0.02$; clayveld sub-sample, wealth categories 1+2 versus categories 3+4: $\chi^2 = 5.95$, 1df, $p<0.02$).

Table 6.3.2.1 The effect of the amount of water used on morbidity
Clayveld sub-sample only

Water-use	N Child Weeks	Morbidity n	Morbidity %	Diarrhoea n	Diarrhoea %	ENT n	ENT %	Sore Eyes n	Sore Eyes %
High	345	135	39.1	45	13.0	51	14.8	20	5.8
Low	328	126	38.4	37	11.2	49	14.9	18	5.5

Notes to Table 6.3.2.1:
Morbidity is defined as in 6.1

Women from each kitchen were questioned at three time intervals about the amount of water carried to the kitchen each day. They were the divided into those which used above, and those below 9 litres per person present per day. Multiple asking of the question enabled corroboration and a dry and wet season rate to be calculated. Where the dry and wet season use levels place the kitchen in different categories they have been excluded from the analysis presented here.

Table 6.3.2.2 The effect of the amount of water used on morbidity
borehole users excluded
Clayveld sub-sample only

Water-Use	N Child-Weeks	Morbidity n	Morbidity %	Diarrhoea n	Diarrhoea %
High	230	93	40.4	37	16.1
Low	303	119	39.3	35	11.5
				$\chi^2 = 2.4$, $p<0.2$ n.s.	

Notes to Table 6.3.2.2:
Categories as in Table 6.3.2.1

Table 6.3.2.3 Amount of water used and child anthropometric status
(clayveld sub-sample only)

Water used	n	Ht/age	σn^{-1}	n	Wt/age	σn^{-1}	n	Wt/Ht	σn^{-1}
High	29	94.90	3.80	28	88.66	10.75	44	97.37	6.34
Low	21	95.05	3.60	22	85.06	8.51	37	95.01	6.24

Notes to Table 6.3.2.3:
Anthropometric status is assessed and defined as in Chapter Five, as percentage of NCHS standard, with a September 1986 timeline.

Height-for-age is very similar, between high and low users.
Wt/Age; the difference is not statistically significant ($t= 1.26$, $p<0.25$).
Wt/Ht the difference is almost significant at the 5% level ($t= 1.66$, 79df.)

Higher use of water was reflected in marginally improved anthropometric status, at least in weight (Table 6.3.2.3). This does not reflect simply the interaction between wealth and water use, as in Chapter Eight it is shown that there is no systematic relationship between wealth and anthropometric status in this population. The anticipated interpretation was that this would be due to lower diarrhoea morbidity of children in kitchens with higher water use. However, this was not the case, as users of larger water volumes had slightly higher diarrhoeal morbidity (Table 6.3.2.2). This difference is more striking when it is considered that on the whole the children in richer households - who tend to use more water - actually experience less diarrhoea (see Chapter Eight). Thus the negative relationship between water use and diarrhoea would be even more negative if it were not for the confounding effect of wealth. Thus in this sample high water-use did not reduce diarrhoeal morbidity in 1986-8, though it may have improved weight (but not height) status (as assessed in 1986).

6.3.3 The impact of borehole water on welfare variables

Some of the clayveld households have access to virtually uncontaminated borehole water, and this section compares their welfare status with children of other households on clayveld.

Table 6.3.3.1 The use of borehole water and morbidity Clayveld sub-sample only

Water supply	n child weeks	n diarrhoea	% diarrhoea
Borehole	156	11	7.1
Others	1280	156	12.2
Wealth category one only:			
Borehole	78	4	5.1
Others	90	3	3.3
Other wealth categories:			
Borehole	78	7	9.0
Others	1190	153	12.9

Notes to Table 6.3.3.1:
Borehole supplies came from two deep tube-wells apparently well maintained and little contaminated. Morbidity definition is as in 6.1

The lower morbidity for borehole users (population as a whole) was almost statistically significant at the 5% level, χ^2, 1df; 3.54 $p<0.1$ nearly 0.05

Controlling for wealth appeared to eliminate much of the relationship between morbidity and borehole water access; although sample sizes are very small, morbidity is similar between people with and without access to boreholes in both wealth category one, and categories 2,3 + 4.

Children in households using borehole water showed much lower diarrhoea in 1986-7 and somewhat lower levels in 1987-8 (Table 6.3.3.1). The difference is almost significant at the 5% level (overall). This affect is largely the result of a bias of bore-hole users towards the wealthy, and therefore there is no evidence that purer water lowers diarrhoeal morbidity. Furthermore, those households with access to a borehole also used more water per person than others in the area (14.2/litres/day per person present as opposed to the population average of about 9/litres/day), so the effect of water purity and water volume are confounded, as found in the Tomkins *et al.* (1978) study. (Note however that high water use *per se* is not shown to lower diarrhoeal morbidity in section 6.3.2).

6.3.3.2 The use of borehole water and child anthropometric status (clayveld sub-sample only)

	n	Ht/age	σn^{-1}	n	Wt/age	σn^{-1}	n	Wt/Ht	σn^{-1}
Bore-hole	16	94.23	4.33	16	89.11	13.60	17	98.54	5.79
Others	37	95.15	3.67	38	86.60	7.69	75	96.19	6.04
		non-sig			non-sig		t=1.44	90df	P<0.1

Notes to Table 6.3.3.2:
Anthropometric status is assessed with reference to NCHS standards with a September 1986 timeline

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The height-for-age status of the borehole and non-borehole users is very similar,* whilst weight-for-age and weight-for-height status is a better amongst borehole users (6.3.3.2). However, it should be stressed that the result is not statistically significant, and the difference small. This is not simply an effect of wealth (see Chapter Eight). An effect on weight but not height was the pattern recorded by Tomkins *et al.* (1978:241), in northern Nigeria.

Table 6.3.3.3 The use of borehole water and the infant mortality rate Clayveld sub-sample only

Water supply	1950-1979			1980-1986		
	n born	n died	IMR	n born	n died	IMR
Borehole	32	1	31	9	0	0
Others	167	23	138	67	6	90
Wealth category one only:						
Borehole	26	1	38	1	0	0
Others	33	1	30	6	0	0

Notes to Table 6.3.3.3:
Only births during the period in which the bore-holes were known to be in operation were included, and one family only started using the bore-hole in 1974 births were only included after that date.

As long term bore-hole users were heavily biased towards richer households the second part of the table was constructed to show that the apparently lower infant mortality of bore-hole users was not independent of wealth status.

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* However, it is nearly one percentage point lower in borehole users.

The use of borehole water apparently greatly lowered infant mortality, but in reality this was largely due to the fact that those families who had been using the borehole for a long time were predominantly the economically privileged. Women in 'wealthy' households have markedly lower infant mortality rates: see Chapter Eight. The association between wealth status and access to boreholes has several causes.[24]

6.3.4 Discussion and Conclusion of the Effects of Water Supplies on Welfare

Considerable differences in water sources between ecological zones exist, but these are little reflected in use rates and seasonal water shortages. Analysis of ecological zone differences in water supplies and the impact of this on welfare were abandoned once it became clear that water use patterns in themselves were responsible for little of the differentials in morbidity, anthropometric status and mortality.

Borehole water use was associated with slightly less diarrhoea, slightly better anthropometric status and lower mortality, but the result is confounded by a wealth-bias towards borehole users, and a 50% higher use of water. The dominant view in the literature has tended to move away from the belief that simple improvements in water purity will lead to better health. Greater attention has been given to the need to improve the quantity of water provided and the overall living and economic conditions of the people. In regard to the quantity of water used it seemed to have no positive effect in this sample. Furthermore, the lower level of water-use by the boundary population had no effect on diarrhoeal and other morbidity. The weakness of the relationships between water supply and diarrhoea tend to support the observations in Section 6.1 that the seasonality of diarrhoea largely reflects food contamination as a function of temperature. Note the research by Khan (1982) and Han and Haing (1989), who found that soap use, rather than simply water use is what lowers diarrhoeal morbidity; soap has this effect by its specific interruption of contamination of food and water by pathogens.[25]

In research in Zimbabwe, Mason *et al.* (1986) found that water supply upgrading reduced helminths rather than protozoal parasites (as predicted by Feachem *et al.* (1983a), on the basis of their different transmission biologies. *Giardia lamblia* was at an even higher level in the communal area community with the piped water supply than that without, for reasons unknown. In a study of the impact of improved sanitation in three African cities Feachem *et al.* (1983b) showed that there was no real lowering of intestinal protozoal parasites by sanitation provision, and in Colombia there was less diarrhoea in children using a public standpipe than amongst those provided with an intra-domicile tap! (Bertrand and Walmus, 1983:208). Some contrary results have also been obtained, suggesting that improved water supplies can be helpful, but some of these results are easy to critique.[26] Surveys in Addis Ababa in the 1970s concluded that personal hygiene and quantity of water used did predict quite well levels of diarrhoea (Freij *et al.* 1979). Sanitation improvements in St Lucia (West Indies) apparently reduced intestinal helminth and diarrhoea, and improved anthropometric status (Henry, 1981); and a study in the western Sudan have found that upgrading of hafirs (which improved the quality, and especially the quantity of water) may have reduced diarrhoea (Awad el Karim, *et al.* 1985). To conclude, Feachem *et al.* (1986) document very clearly how complex will be the effect water supply provision improvements on health, and Blum and Feachem (1983) how rigorous studies will have to be to demonstrate these effects. Thus the existing literature supports the conclusion that direct and simple effects of water supply are indeed unlikely.

Community well-digging and up-grading has been conducted in association with this research, through an indigenous NGO managed by Z. Phiri Maseko. The effect has been to improve both water quality and quantity, and to reduce women's collection times. This offers the potential for useful research to test whether diarrhoeal morbidity will now decline in the villages involved.

6.3.5 Effects of Sanitation on Morbidity

Until recently there were very few pit latrines in Mazvihwa (Table 6.3.5.1); latrine use extension has been one of the policy planks of the new primary health programme (see Chapter Nine for a review of this programme and its effects). Prior to latrine use there was a fairly effective use of designated areas of bush,[27] but most people were now convinced that there was no longer the space or cover for defaecating in the open, and also that modernity requires latrines. Therefore it can be tested whether improved sanitation has an impact on diarrhoea.

Table 6.3.5.1 Historical Changes in Pit Latrine Use in Mazvihwa

	First Latrine Constructed: Pre 1975	1975-1979	1980-1986	Under Construction	None
Number	4	3	10	30	22
Percent	6%	4%	14%	43%	31%

Notes to Table 6.3.5.1
The time line for the assessment of pit latrines was late 1986. The Table indicates when households first constructed pit latrines. Several households that completed pit latrines before Independence (1980) have since constructed new and better latrines using cement. Most of the latrines under construction were awaiting the cement promised to latrine builders by the Ministry of Health. Those not constructing latrines were divided between those who said that they were incapable of constructing latrines (too weak/too poor, etc.) or used those of neighbours, and those who thought latrines were pointless (and that 'defaecating in houses' was outrageous) and/or latrine use was likely to increase ill-health. According to a national data source in 1984, an almost identical figure of 76% of rural Zimbabweans were not using pit latrines (Raath, 1985).

Data were not available for 1 (1%) of households.

Table 6.3.5.2 The Effects of Latrine Ownership on Diarrhoeal Morbidity Clayveld Sub-Sample Only

Wealth Category	With Latrine (Households)	Without Latrine (Households)	With Latrine: N Chd Weeks	N Dia	% Dia	Without Latrine: N Chd Weeks	N Dia	% Dia
1	6	3	111	5	4.5	57	2	3.5
2	3	6	53	14	26.4	103	15	14.6
3+4	2	18	31	5	16.1	412	56	13.6

Notes to Table 6.3.5.2
N Chd Weeks, refers to the number of weeks sampled by recall data, for children under ten in that category, in the same manner has been used elsewhere in this thesis (this chapter, and Chapter Eight). N Dia, refers to the number of those weeks in which the child is said to have experienced diarrhoea. The time period for thes observations is mid 1986 to mid 1988.

Latrine ownership refers to late 1986, as few, if any of the latrines being built were completed prior to early 1988, as the cement that had been promised by the Ministry of Health was not delivered. Ownership is not equivalent to use, however, as some owning latrines may still use the bush and some without latrines had arrangements with their neighbours. However, use was not possible to accurately assess.

For discussion of the concept and socio-economic factors involved in wealth categories see General Methods and Chapter Four. For this analysis wealth categories three and four had to be combined due to the small number of latrines built by these poor households.

For each wealth category, those owning latrines actually experienced higher diarrhoeal morbidity than those without. In the case of wealth category two this result was nearly statistically significant (χ^2= 3.2, 1df, p<0.1).

There is a strong association between latrine ownership and wealth, and therefore study of the impact of latrines upon diarrhoeal morbidity must control for this fact, as, in the clayveld sample, the wealthiest children experience the lowest diarrhoeal morbidity (Chapter Eight, Section 8.3). Therefore in Table 6.3.5.2 the effects of latrine ownership on diarrhoeal morbidity are analyzed for the clayveld population with the households stratified by wealth.

It appears that the ownership of latrines has little effect on diarrhoeal morbidity. In fact, if anything, latrine ownership is associated with higher diarrhoeal morbidity (Table 6.3.5.2). Thus the suppositions of many local people that pit latrines are proving unhealthy have been somewhat substantiated by the quantitative data.

Field studies of the effects of latrines on diarrhoea are now reviewed. In a study of differences in disease patterns in 'westernised', 'semi-traditional' and 'traditional' Africans in pre-Independence Zimbabwe, Donaldson found that there essentially no differences in the level of gastro-enteritis. This he attributed to the fact that fly control will not be effective 'until almost 100% latrine control is established in a given area' (1971:52). However, the use of latrines - together with less crowded conditions - was correlated with lower post-neonatal infant mortality in two Bangladeshi villages in the 1970s (Raham *et al*., 1985); and in the rivereine Sudan a study found those using deep latrines had lower diarrhoeal incidence than those relying on shallow faecal disposal (El Samani *et al*., 1988:104). In a study I undertook with colleagues in Southern Sudan, that compared the percentage of people infected with intestinal helminths (mostly hookworm and *Strongyloides*) with the proportion of the population owning pit latrines in five refugee settlements, discovered an exceptionally good correlation (Wright, in Wilson *et al*., 1985:109). However, though intestinal helminth infection was correlated with abdominal pain (1985:111), no attempt was made to investigate whether intestinal helminths were making a significant contribution to diarrhoea. (A relationship between faecal disposal and infection would be expected to be most common in parasites that infect via the feet/skin rather than mainly orally.)

Although the great potential contribution of latrines to improved health is taken as a basic fact in primary health care, negligible field research has been undertaken to investigate this in Africa. As in the case of improved water supply, careful control for socio-economic factors needs to be made in such research. Assumptions that since many diarrhoea causing pathogens have oral-faecal transmission, simply 'better' disposal of faeces will lead to automatic reductions in diarrhoea, prove naive. What may turn out to be critical is rates of food and water contamination from hands or other items, and therefore what actually happens to the faeces actually immaterial. It has already been shown that water contamination at source is not a factor in this population (Section 6.3.3). This line of argument is supported by the results of studies of the great effectiveness of soap use in reducing diarrhoea that have been undertaken in Asia (Khan, 1982; Han and Haing, 1989). If flies are an important disease transmitting agent, then the effects of latrines upon fly populations and their proximity to dwellings will be critical. Often ignored by public health workers is that sites of bush defaecation are often far from homes, whereas flies hatching in latrines are right on-site. Zimbabwe has developed latrines (the Blair toilet) which, if properly constructed allow very few flies to escape (Morgan, 1977; Pugh, 1978c:77). However, most of the latrines in use in Mazvihwa are not of this standard, and it is unclear how quickly the new design will become rigorously followed. Further research is therefore required into whether the effects of Blair pit latrines will be positive, and into methods of ensuring high technical adoption rates.

In conclusion, sanitation - at least as reflected in ownership of pit latrines - is not affecting levels of diarrhoea in Mazvihwa. Such technologies, therefore, are not enabling the wealthy to escape the ecological determinants of diarrhoeal morbidity.

Section 6.3.6 Effects of Household Cleanliness on Morbidity

The studies in this section of the impact of sanitation and water supply on morbidity (especially with diarrhoea) have suggested that if there are relationships they are weak, and possibly even in the opposite directions to those predicted. The main reason for this is argued to be the fact that within household cleanliness/sanitation factors actually dominate the spread of faecal-oral and other infection. In this section I make a first step towards testing this hypothesis.

Ideally a whole range of investigations should have been made into levels of contamination of food and water stored and consumed within the homes, of soap usage, contamination of hands, bedding, etc. Whilst such research is urgently required in rural Africa, it will require very well thought out methodologies and technical back-up. Apart from questions about general levels of soap use, which I could so easily have asked about, these questions were all beyond my own research capacity at the time. Therefore, I am required to use a measure I collected as a proxy for household cleanliness, that is the frequency of sweeping of the homestead yard. Almost all households have a regular timetable on which they clean the yard: either once, twice or three times per week. Whilst there are problems with taking this as a good proxy for cleanliness, and with the method used to collect the data (see notes to Table 6.3.6.1), the measure is still likely to reveal possible relationships. Some of the effects of sweeping are, of course, likely to be of direct benefit to morbidity in that much dirt is removed from the area in which children spend much of their time playing.

Apparently yard sweeping frequency has a close relationship to levels of diarrhoeal morbidity, at least in all but the richest households (Table 6.3.6.1). Yet the richest households do not sweep the yard any more frequently than do other households, and therefore this particular measure of cleanliness cannot explain why the wealthy children in the clayveld sample experience lower morbidity (Chapter Eight). It is worth comment that high levels of water use, borehole water use, and ownership of pit latrines are all correlated with wealth, and are associated with modernity, but show no effect on diarrhoea morbidity. Sweeping, on the other hand, shows marked effects, but is a matter for little pride, or at least not a factor in modernity, and (so?) does not vary with wealth. A more careful examination of domestic hygiene might have identified even stronger relationships. A study of this kind would seem sensible in order to formulate health education messages; not least because existing primary health programmes seem rather misguided.

Table 6.3.6.1 The Effects of Frequency of Sweeping on Morbidity
Clayveld Sub-Sample Only

Wealth	Less Than Twice/Week					Twice Per Week					More Than Twice/Week				
	N Chd Weeks	Morb	Diarr	ENT	Sore Eyes	N Chd Weeks	Morb	Diarr	ENT	Sore Eyes	N Chd Weeks	Morb	Diarr	ENT	Sore Eyes
1	33	3	0	0	1	64	24	4	11	2	22	13	2	3	4
2+3+4	53	22	15	3	2	46	19	7	4	3	46	19	7	4	3

Comparison of Diarrhoeal Morbidity Levels by Sweeping; Holding Wealth Constant

Wealth	Less Than Twice/Week N Chd Weeks	Diarrhoea n	Diarrhoea %	Twice or Over/Week N Chd Weeks	Diarrhoea n	Diarrhoea %	Stat Signif χ^2
1	33	0	0	86	6	7.0	samp too small
2+3+4	53	15	28.3	270	39	14.4	6.9, 1df, p<0.02

Notes to Table 6.3.6.1
The frequency of sweeping the household yard was determined by interviewing women, usually the head of individual kitchens. Portions of the yard may be swept from time to time because they get particularly dirty, but sweeping frequency for the whole yard is 'known' in that it is usually allocated specific days, notably those days in which ancestral spirits and the churches ban the opening of the soil; chisi, Wednesday in this area; and Sunday (or Saturday in the case of Apostolic church members). Furthermore sweeping is usually allocated to specific individuals in turn (usually young girls or junior wives) so that rotas do tend to be followed. However, it should be stressed that the figures are not based on direct observation and monitoring. Some women commented that there are seasonal variations in yard sweeping, notably that the yard has to be swept more often in July, which is the windiest month. No account was made of this seasonal variation in data presented in this table. Also important is the fact that yards vary in size, and that this can lead to variation in the frequency of sweeping independently of cleanliness factors. Also it may be that households which are generally dirty - eg. due to a large number of ill-controlled children - could actually appear to be 'clean' by this analysis simply because the women have to sweep the yard more often as a result.

Wealth category one was separated from those of 2, 3 and 4, since it is only wealth category one that shows systematic differences in morbidity in the clayveld sub-sample (Chapter Eight, Section 8.3). For details of wealth categories and what they constitute see General Methods, and Chapter Four.

N Chd Weeks refers to the number of weeks of retrospective morbidity monitoring undertaken for children in this class (ie. sample size). Morb refers to overall morbidity, diarr to diarrhoea, ENT to ear, nose and throat and other respiratory infections. For details of these ailments see Section 6.1.

As only diarrhoea appears to show variations with frequency of household sweeping, only this sub-sample was tested. Whilst amongst the wealthy households increased sweeping appears to raise diarrhoeal morbidity, the sample size was too small to test for statistical significance. In contrast the large sample size in children of wealth categories 2, 3 and 4, more frequent sweeping is clearly reflected in lower diarrhoeal morbidity.

To conclude, the fact that frequency of sweeping reduces diarrhoeal morbidity supports the conjecture that household cleanliness factors may be the most significant in determining levels of infection, rather than the more distant factors of water supply and latrine use. Similar conclusions can be derived from a critical examination of the other study that investigated cleanliness of the domestic environment (Huttly *et al.*, 1987:866-7). It is these hygiene factors that may well mitigate ecological processes controlling the dynamics of seasonal and inter-annual vulnerability. For example, the use of soap and clean work surfaces/yard during food preparation and storage may reduce food contamination, and hence the propensity for seasonal increases in diarrhoea with temperature (as found in Section 6.1.4). Be this as it may, I have still not been able to find what (if any) cleanliness or sanitation factor/s is/are responsible for lower morbidity (especially in diarrhoea) amongst the children in the wealthiest households (Chapter Eight).

6.3.7 Conclusions to Section 6.3

This section examined whether water supply and use, sanitation and cleanliness factors are shaped by, or are able to mediate between, seasonal and inter-annual variations in the ecological determinants to morbidity, and some other welfare factors. By and large water supply and sanitation show very limited effects. In a sense this illustrates the strength of ecological determinants relative to the technological interventions available; but also reflects the fact that the determinants of contamination and disease transmission operate at the much finer level of domestic hygiene. It is at this latter level that scope exists for the generation of 'micro-climates' somewhat insulated from ecological processes. This is illustrated by the effects of the frequency of sweeping, and studies of factors such as soap use might well explain how the wealthiest in this population achieve lower diarrhoeal morbidity (cf. Chapter Eight).

6.4 Morbidity and Anthropometric Status

A body of research suggests that small body size in infants and children, and more particularly low weight rather than height, increases the susceptibility to disease, and/or lengthens the period of morbidity. Therefore it is necessary to examine this relationship to link the argumentation in Chapter Five (Nutrition) with this chapter on morbidity. Diarrhoea is notably important in this regard, and is the most important cause of death in children in this population (Chapter Seven, Section 7.2.1); therefore I will focus attention on it. Although diarrhoea appears to show little relationship to certain sanitation factors in this area (Section 6.3), a whole range of factors linked to greater infant and child welfare vulnerability are associated with higher diarrhoeal morbidity (Chapter Eight). After a brief overview of the nutrition-morbidity literature, this section therefore examines in some detail whether there are links between diarrhoeal morbidity and anthropometric status. I examine both whether low birthweight and poor anthropometric status increases subsequent risk of morbidity (especially diarrhoea), and whether high diarrhoea results in poorer growth.

The existence of a 'vicious cycle' synergistic relationship between malnutrition and morbidity has been fundamental to the nutrition literature for many years (Scrimshaw *et al.*, 1968), though detailed evaluations have remained critical of blanket statements (eg. see Carmichael, 1985). An important recent review (Tomkins, 1986) has stressed the need to consider the distinction of the effects of severe PEM from the mild and moderate, and to address relationships at four stages in the course of infection (incidence, severity, duration and outcome). He also stresses the differential effects of immunological competence changes in mild/moderate malnutrition (1986:293-5), so that each infection must be considered in its own right. Although Tomkins' paper is perhaps more important for its rigour than its conclusions, these conclusions are worth detailing as a 'state of the knowledge' position. For mild/moderate malnutrition, Tomkins finds that there is little effect on incidence (that is, stage one), and outside of measles little data for an effect even of severe malnutrition. However, in contrast, there was a fair (though still inadequate) amount of evidence linking mild/moderate malnutrition to increased duration of infection, greater functional impairment and higher probability of death (stages 2-4). This kind of questioning has re-opened debates, even about measles, though it is difficult to avoid the conclusion that nutrition plane is a highly significant (if not the only) factor effecting outcome of infection.[28] In addition to drawing attention to the need for physiological rigour in nutrition-morbidity research, Tomkins makes a plea to consider:

'PEM as a risk factor for infection not just as a biological influence on immune response or physiological function during an infective process, but as a marker for those who are without sufficient resources to survive in the environment' (1986:302).

The limited research on the link between respiratory infection and nutritional status has suggested that there is little effect on incidence, but some on duration (James, 1972:692; Sommer *et al.* 1984).

There is a large body of high quality research showing an interaction between nutritional status and diarrhoea (for reviews see Chen and Scrimshaw, 1983; Martorell and Ho, 1984; Black, 1984). Diarrhoea certainly contributes to growth faltering (Levinson, 1974; Rowland *et al.* 1977; Mata *et al.* 1976; Martorell *et al.* 1975; Bairagi *et al.* 1987). Detailed prospective studies in Uganda and the Gambia found through regression that nearly all of the deficit in weight gain could be explained by morbidity alone; though in fact when season was controlled the effect was less significant (Cole and Parkin, 1977:197-8). Gastro-enteritis was the most important contributor at a population level (Cole and Parkin, 1977:197-8). The physiological and behavioural mechanisms involved are still relatively little known, and it can be pointed out that vulnerability to weight loss with diarrhoea can itself be a function of poor nutritional status and low food availability (Rowland and Cole, 1980; Whitehead *et al.* 1976).

A number of prospective studies have been undertaken to show the effect of anthropometric status on subsequent diarrhoeal morbidity levels, seeking to identify the functional significance of reduced immunocompetence (cf. Cunningham-Rundles, 1982; Martorell and Ho, 1984; Fakhir *et al.* 1989). These studies have generally monitored gastro-enteritis in a more satisfactory way than myself, and have separated incidence, duration, and the percentage of time ill. The most influential studies have found that the duration (and perhaps severity) of the diarrhoea, rather than the incidence, is greatest in lighter children (James, 1972:691 [at least in children of 1-36 months]; Tomkins, 1981b; Black *et al.* 1982 and Black, 1984; Bairagi *et al.* 1987).[29] Other research suggests that incidence of diarrhoea is greater in poorly nourished children, especially with low weight rather than height (in Haiti: Graitcher *et al.* 1981; El Salvador: Trowbridge *et al.* 1981; Guatamala: Delgado *et al.* 1983; Nigeria (Tomkins, 1981a);[30] and Sudan: El Samani *et al.* 1988:103). On the other hand height-for-age was found a better indicator by Tomkins *et al.* (1989). Some of these studies (eg. James, 1972 and Tomkins *et al.* 1989) try to control for socio-economic variables, but the absence of recorded differences does not prove that there are not others confounding the result. In my study, for example, there were varied relationships between anthropometric status and wealth (see Chapter Eight), and diarrhoea was less common amongst the children in the wealthiest households (except for the outsider children in the Boundary sample). Thus controlling for wealth requires very detailed knowledge of the relationships between sub-samples of the population and the different variables.

Furthermore, these prospective studies, like my own, generally start with children who are already underweight from causes unknown, but it is assumed that it is this underweight status that causes elevated subsequent diarrhoeal morbidity. Yet the association between being underweight and high diarrhoea during observation could arise solely from the weight depressing effect of diarrhoea (discussed above). Those children who are 'inherently' more vulnerable to diarrhoea (eg. for a genetic/physiological reason unconnected with nutritional status) will become underweight by the start of monitoring and continue to have higher diarrhoea during observation, without the poor nutritional status itself actually contributing to the increased morbidity. The recent study of 24 Sri Lankan children, for whom birthweight is known, is useful in reinforcing the interpretation* in this regard as low birthweight is associated with high diarrhoeal morbidity beyond the first year of life, an effect independent of basic economic status, age, birth order and feeding mode (Mertens *et al.* 1987). Similarly, an effect of diet supplementation during pregnancy in Toronto was not only more vital neonates, but also lower morbidity in infants at six months (Ebbs *et al.* 1941:524). However, it is worth observing that an examination of the effect

* that it is nutritional status that is responsible for diarrhoeal frequency

of birthweight on subsequent morbidity in this sample showed no such effects (see below).

It appears that vulnerability to morbidity, including with diarrhoea, is not established at birth by birthweight, and then maintained through infancy and childhood (Table 6.4.1). Indeed babies heavier at birth showed (surprisingly) a higher morbidity level than those of relatively low birthweight, especially in the earlier period of life. There is no ready explanation for this phenomenon.

Table 6.4.1 Birthweight effects on morbidity clayveld sub-sample

(a) children aged two to ten

B'weight	n-child weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore Eyes n	Sore Eyes %
Over 3kg	24	16	67	3	13	8	30	1	4
Under 3kg	26	14	54	4	15	9	35	0	0

(b) under two year olds

B'weight	n-child weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore Eyes n	Sore Eyes %
Over 3kg	47	36	77	18	38	11	23	7	15
Under 3kg	20	10	50	6	30	2	11	0	0

Notes to Table 6.4.1:
Relatively high and low birthweight have been separated at 3kg, which is near the average for this population. Relatively low birthweight in this analysis (less or equal to 3kg) should not be confused with the scentific definition of 'low birth weight' (under 2.5kg).

The reference date for age definitions is September 1986. Therefore during the period of observation (June 1986 to June 1988) most of the children defined as under two passed the age of two, but were kept in this category [part (a) of the table]. No children who passed the age of ten were included. In practise the earliest birthdate with known birthweight in 1981.

Sample size is very small. In the over 3kg category there were three children over two and six children under two. In the under 3kg group there were four children over two and three children under two.

Higher birthweight children record higher morbidity in all disease and age categories except diarrhoea over two years old. Specific sub-samples are generally too small to be tested with χ^2. However, overall morbidity is higher in the children born over 3kg in the under two years old bracket (χ^2, 1df, = 4.61, $p<0.05$)

Table 6.4.2 Interactions of prior anthropometric status and subsequent diarrhoea: clayveld sub-sample

	Ht/Age n	Ht/Age mean	Ht/Age σn-1	Wt/Age n	Wt/Age mean	Wt/Age σn-1	Wt/Height n	Wt/Height mean	Wt/Height σn-1
High Diarr.	10	94.17	5.02	11	81.17	8.73	14	94.27	6.35
Low Diarr.	43	95.03	3.37	43	88.91	10.01	77	96.76	7.15

Notes to Table 6.4.2:
High diarrhoea was defined as 20% or more of the 'illness in one week' recall questions recording diarrhoea. Low diarrhoea was morbidity with diarrhoea below this level. The period of morbidity observation was between mid 1986 and mid 1988, during part of which the records were bimonthly, and part opportunistic. Between five and ten percent of the time in this period was covered in the actual weekly recall periods.

Diarrhoea is highest in children under two. Height data is unfortunately unreliable in this age-group and weight-for-age data cannot be used without careful age-stratification as below the age of two years the variable declines rapidly with age. This means that the sample for high diarrhoea is small, and may not be representative of the most 'at-risk' category, who are undoubtably the under twos.

The reference date for the anthropometric measures is September 1986, that is it represents status PRIOR to collection of morbidity data. NCHS standards are used, see Methods Chapter for details.

Ht/Age and Wt/Height are both higher in the low diarrhoea category, but not statistically significantly so. Wt/Age is significantly lower in the high diarrhoea category (t= 2.49, 52df, p<0.025)

6.4.3 Changes in weight-for-age before, during and after high diarrhoeal incidence: clayveld sub-sample

	BEFORE Wt/Age Sept 1986			DURING Wt/Age Jan 1987			AFTER Wt/Age June 1988		
	n	mean	σn-1	n	mean	σn-1	n	mean	σn-1
High Diarr.	5	81.24	5.68	5	86.9	7.22	5	86.3	11.33
Low Diarr.	26	88.64	9.39	26	89.2	9.25	26	92.3	8.65

Notes to Table 6.4.3:
The only children included are those for whom there are weight-for-age data for each time interval, and the children started above two years of age to avoid systematic trends in weight-for-age with growth. Note that anthropometric status was expected to be higher in Jan 1987 than Sept 1986, because this is a clayveld sample where the children improve in weight with the rains. Higher status in June 1988 reflects improvements seen in the post-harvest period after the first good rainy season in three years. For details of this underlying dynamic in nutritional status see Chapter Five.

Wt/Age is only significantly different at the start of the series (t= 1.65, 29df., p almost 0.05)

Low anthropometric status by weight-for-age (and possibly weakly with Ht/Age and Wt/Ht) is associated with higher subsequent levels of diarrhoeal morbidity (Table 6.4.2). However, during this period of monitored increased morbidity (which was also a period of extreme drought followed by a good harvest) weight-for-age differences reduced between the child categories experiencing high and low diarrhoea (Table 6.4.3). It should be noted that the method of diarrhoeal surveillance used covered only around five to ten percent of the time over the two-year study, so that it only measures propensity to suffer diarrhoea, rather than the actual total rate experienced. Whether this propensity to contract diarrhoea is itself linked to the difference in anthropometric status recorded at the start of the observation period cannot be determined for certain (see introduction). Equally, the fact that nutritional status in respect to diarrhoea morbidity levels declines somewhat through the period of monitoring could be interpreted as evidence of a rather weak relationship between the two. Alternatively this could be due to the fact that the children are aging during the two years of monitoring. (As they get older they become less vulnerable to diarrhoeal morbidity, and/or less likely to lose weight when they do experience diarrhoea.)

Taken as a whole, however, the results nevertheless suggest that levels of diarrhoeal morbidity do have some impact on child anthropometric status, and that low anthropometric status does increase the propensity to suffer diarrhoea.

A note of caution should be sounded in that this evaluation of anthropometric status and diarrhoea has been conducted in only one of the three ecological zones: that of clayveld where peak diarrhoea and peak weight gain actually tend to coincide on a seasonal basis. The relationship between anthropometric status and diarrhoea may therefore be much stronger in sandveld.

6.5 Concluding Discussion to Chapter Six

This chapter has investigated aspects of the ecology of morbidity, and its relation to anthropometric status. The most important question answered was whether differences between the ecological zones create sufficiently different disease-environments to produce opposite seasonal and inter-annual child morbidity patterns for a number of ailments. It was predicted that in sandveld a 'moist savannah' pattern of higher morbidity in the wet season would occur, whilst in the clayveld the dry season would be the time of highest morbidity. Dry years were predicted to elevate morbidity only in clayveld. The data examined for the period 1986-8 supported this hypothesis, but the pattern was not entirely clear cut.

Disease seasonality is examined at some length (Section 6.1). Overall morbidity showed the expected pattern of opposite seasonality between ecological zones in severity in the first year of study, but not in the less closely monitored second year. Several ailments showed clearly contrasted seasonal patterns between the ecological zones (eg. sore eyes) or probable seasonal contrasts (ear/nose/throat [ENT] and respiratory infections and measles). Diarrhoea showed similar seasonal patterns and levels in all zones and between years. This result, combined with literature review and analysis of the interactions between water supply, sanitation, cleanliness and diarrhoea (Section 6.3) is used to argue that the seasonal cycle is largely a result of changing temperatures effecting food contamination rates.

Inter-annual variation in morbidity was examined through comparison of rates during and after a period of two years drought (Section 6.2). Differences in the level of morbidity were marked, but the patterns were not entirely clear in respect to the hypothesis that clayveld should experience greater morbidity elevation in drought than sandveld. This was basically due to irregular fluctuations in the rate of ear, nose and throat [ENT] and respiratory infections. Changing patterns of overall morbidity with ENT infections excluded were therefore examined. This confirmed the prediction that drought elevated morbidity only in clayveld and not sandveld and boundary populations. This morbidity evidence can now be combined with the data on nutritional vulnerability and birthweight to explore the causes of ecological differences in inter-annual mortality differentials (Chapter Seven).

Soil type differences between the ecological zones are reflected in water supplies, but there is little evidence that water supplies alone are responsible for differences in disease seasonality or levels (Section 6.3.5). Relatively high levels of water use by kitchens are correlated with marginally better child weight, but this was apparently not due to lower morbidity. Children in bore-hole water using households had marginally lower diarrhoeal morbidity, slightly better weight and lower infant mortality. However, bore-hole water using families were mainly relatively wealthy, and when wealth was controlled there was little effect of bore-hole water usage on welfare. Likewise when wealth was controlled, pit latrine ownership did not contribute to lower diarrhoea (Section 6.3.5). However, in contrast, domestic hygiene may be able to reduce morbidity, as illustrated by the diarrhoea reducing effect of the frequency yard sweeping (Section 6.3.6).

Seasonality in child morbidity has been shown to drive much of growth seasonality in savannah Africa (eg. Waldemann, 1973; McGregor *et al*,1970; Cole and Parkin, 1977; Thompson, 1977; Billewicz and McGregor, 1982:317; Thompson *et al.* 1986). Contrasting morbidity patterns between ecological zones may thus contribute to creating the different seasonalities and inter-annual variation in growth (Chapter Five). Indeed, there are relationships between diarrhoea and individual growth rates demonstrated in this sample (Section 6.4). Above and below average birthweights, however, actually show the reverse pattern of morbidity to that predicted by a hypothesis of determination by nutritional status. An overall understanding of the role of morbidity in growth retardation - and vice versa - is clearly beyond the reach of the present investigation; nevertheless the current evaluation makes important links between Chapters Five and Six and lays foundation for discussions of mortality (Chapter Seven) and household differentation (Chapter Eight).

Attention to child morbidity has made a substantial contribution to tracing the links between savannah ecological dynamics and human welfare. Seasonality in morbidity clearly combines with seasonal food supply in creating opposite seasonality regimes in the two ecological zones (see also Chapter Five). Drought year morbidity is also elevated in only the clayveld zone, and thus it may also contribute to greater growth faltering in this particular zone but not the other two (cf. Chapter Five). Child morbidity levels have also been used to test hypothetical relationships with anthropometric status and water supply sanitation and hygiene; this provides foundation for the examination of issues of differentiation and gender and their impact upon child welfare (Chapter Eight).

CHAPTER SEVEN

POPULATION:

VARIATIONS IN FERTILITY AND MORTALITY, AND SEX DIFFERENTIALS

Introduction

This chapter proceeds further with analysis of the human biological impact of the underlying contrasts in ecological dynamics between the sandveld and clayveld zones as outlined in Chapter Three. Since food production and consumption (Chapter Four), birthweight and growth (Chapter Five) and morbidity (Chapter Six) each appear to reflect marked differences in dynamics between the zones, this chapter examines seasonal and inter-annual variation in fertility (7.1) and inter-annual variation in mortality (7.2). (It is unfortunate that data concerning the seasonality of mortality was not collected.) Birth seasonality is examined as a possible function of ecological dynamics, and then as a result of labour migration holiday patterns. The literature on inter-annual variation and impact of rainfall and famine upon fertility and mortality in Africa are then examined, and on the basis of this, fertility and mortality are predicted to demonstrate opposite inter-annual patterns in the same way as the other welfare variables: sandveld populations should show improved status in dry years, and clayveld populations should be better off in wet years. This hypothesis is confirmed for mortality and marriage rates, but not for yearly variations in birth rates. Literature is then reviewed to implicate the contrasting birthweight dynamics (Chapter Five, 5.1) as a major cause of infant mortality rate fluctuations. Child nutritional and morbidity factors as mortality determinants are also reviewed theoretically in light of other empirical studies.

Section 7.3 examines mortality relations with birth order and birth interval, and 7.4 sex differentials in nutritional status, morbidity and mortality. This latter material is useful for certain elements of the analysis in Chapter Eight, which explores socio-economic determinants of mortality and other welfare differentials.

This chapter considers mortality and fertility in relation to ecological dynamics. In Chapter Eight mortality differentials by wealth, maternal education and religion are explored, and in Chapter Nine historical changes in mortality and fertility are addressed.

7.1 Fertility : Introduction

This section examines four phenomena. Seasonal variations in birth rates (7.1.1), inter-annual variations in marriage rates (7.1.2), inter-annual variations in birth interval and birth rate (7.1.3), and overall contrasts in human fertility (7.1.4).

There has been some literature on the relationship between various eco-physiological factors and human fertility, which can enable hypothesis formulation and investigation of seasonal and inter-annual variations in fertility. Frisch (1975, 1980) has developed and popularized the concept of female 'critical fat' levels being essential for fertility. Great impact on fertility from the stresses of poor diet and high workload has been argued for peasant cultivators by Mosher (1979) amongst others, though without sufficiently detailed data presentation.

Age of menarche is indeed related to various nutritional, physiological and socio-economic factors. For example, poor high altitude populations in the Himalayas, and other areas show characteristically later onset of menarche (Malik and Hauspie, 1986). In another example, the women with higher levels of fatty tissue in one malnourished population did have higher fertility (Mueller, 1979); though the author noted that this relationship may not have been causal, as the wealthier (and fatter) women in this population independently had higher fertility. Howell (1979:192-211) has applied this approach to a detailed study of the Dobe !Kung, suggesting fairly general conclusions, although studies of hormone levels in these populations suggest that unusually low gonadal steroid levels and little corpus luteum function might mean that the ovaries are abnormally sensitive to nutritional status (Van de Walt and Jenkins, 1978).

The general attitude of demographers to the impact of malnutrition on fertility has been that the effect is marginal (Bongaarts, 1981; Mosley, 1978). However, more recent work on the relationship between nutritional status and lactational amenorrhea, is beginning to suggest that fertility (especially birth interval) may be quite vulnerable to the low nutritional plane of the mother (Chen *et al.* 1974:296; Delgado *et al.* 1978; Lunn *et al.*

1980 and 1981; Dobbing, 1982; Rosetta, 1988a:107-8). This nutritional plane is known to reflect both the balance of changing food intake and energy (work) expenditure, but also levels of maternal morbidity that can vary both seasonally and inter-annually. It has even been suggested that male fertility is vulnerable to the effects of drought (Rogo *et al.* 1985; quoted in Ferguson, 1987).

Famines have characteristically (though not always) lowered fertility (eg. Stein *et al.* 1975:74-6; Stein and Susser, 1978; Faulkingham, 1977:153-4; Seaman and Holt, 1975b; Caldwell, 1984:5; Watkins and Menken, 1985:656-7; de Waal, 1989b:174-5), although in addition to declines in nutritional status, the reasons for this are recognised to include psychological stress, declines in libido, social disruption with physical separation of spouses, and deliberate fertility reduction (cf. Bongaarts, 1980). An interesting observation made in the study of the Dutch 'Hunger Winter' was that there were class differentials in the degree of fertility depression (Stein and Susser, 1978). A combination of depressed fertility during famine, and elevated infant mortality resulting in the ending of lactational amenorrhoea means that famines are typically followed by a period of hyper-fertility (Stein and Susser, 1978; Faulkingham, 1977:154, though not always: see Watkins and Menken, 1985:656-7 on Bangladesh 1974-5). (It should also be noted, though, that some of the evidence for reduced fertility in famine is actually disguised infant mortality: Caldwell, 1984:12, see also Section 7.2.).

Morbidity can interact with poor nutritional stress to reduce fecundity (Bantje, 1988:199-200), as well as act directly to reduce coital frequency (Bantje, 1988:200). Time and again attempts to discuss 'natural fertility' and hence by implication how fertility is disrupted by physiological stress, have foundered on our lack of knowledge of coital frequency and its determinants (cf. Robinson, 1986 on this general issue).

Drought might actually be expected to lead to increases (rather than decreases) in fertility in moist savannah regimes where it does not so influence nutritional intake and socio-economic systems as in the drier regions, but does improve disease environment (Chapter Six). In the Gambia fertility did increase in a run of dry years, despite lower mortality; this was said to be due to an improved disease environment (Billewicz and McGregor, 1981:233). In contrast drought in semi-arid savannahs would be expected to reduce fertility by enhancing physiological stress; as well as by promoting greater out-migration of men and other socio-economic disruption.

In conclusion of this literature review, there is some preliminary evidence that levels of nutritional and other physiological stress can affect fertility; therefore it can be predicted that there may be differences in the dynamics of seasonal and inter-annual fertility levels in the contrasting sandveld and clayveld Mazvihwa populations.

7.1.1 Birth Seasonality

Introduction

If 'environmental stress' as examined in this thesis affects birth seasonality, conception and birth should follow opposite seasonal patterns between the two ecological zones, as predicted by their contrasting ecological dynamics (Chapter Three), and revealed in other human biological factors (Chapters Five and Six). Maternal nutritional status and health should be best during the rainy season in the clayveld, and the dry season in sandveld. Drought years would be expected to enhance the existing seasonal regimes.

Notes on data source and methods:
246 exact birth months for births between 1975 and 1986 were collected, mainly from the Road to Health cards, as part of the demographic and nutritional studies.

Gestation has been assumed constant at nine months. Numbers of pre-term births is almost certainly too low to distort seasonal birth patterns. Although seasonality in levels of pregnancy wastage is likely, this could not be directly investigated in this study.

Seasonal and monthly distribution of conceptions

The monthly distribution of conception and births is presented in Table 7.1.1.1, and the seasonal patterns in Table 7.1.1.2. There are no broad seasonal shifts, and no systematic differences between the ecological zones.[1] Despite lack of broad seasonal changes, peaks in conception occur in the individual months of April, December-January and in June. This pattern is less marked in the boundary population. Possible reasons for these peaks are discussed in the conclusion.

Table 7.1.1.1: Seasonality in frequency of births and conception by zone

Birth month:		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Concept month:		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
	n												
$Sand_1$:	29	4	3	2	3	1	2	0	1	4	3	5	1
$Sand_2$:	61	9	2	9	5	4	5	4	4	6	4	2	7
Bound:	71	3	4	5	4	9	6	10	4	7	7	4	8
Clay:	85	13	6	7	5	6	7	4	7	6	10	8	6
Total:	246	29	15	23	17	20	20	18	16	23	24	19	22

Notes to Table 7.1.1.1
'$Sand_1$': the population on sandveld in Mototi
'$Sand_2$': the population on sandveld in Mutambe
'Bound': the population on the boundary between sandveld and clayveld in Mototi
'Clay': the population on the clayveld in Mototi

Table 7.1.1.2: Seasonal conception frequencies between ecological zones

Concept season:		Post-harvest (M/A/M)		Cold-dry (J/J/A)		Hot-dry (S/O/N)		Rains (D/J/F)	
	N	n	%	n	%	n	%	n	%
$Sandveld_1$:	29	8	28	6	21	3	10	12	41
$Sandveld_2$:	61	18	30	18	30	13	21	12	20
Boundary:	71	15	21	18	25	20	28	18	25
Clayveld:	85	25	29	18	21	18	21	24	28
Total:	246	66	27	60	24	54	22	66	27

Notes to Table 7.1.1.2
Populations as in Table 7.1.1.1

Seasonality of conception in dry versus wet runs of years

Seasons of conception in wet and dry years are presented in Table 7.1.1.3. None of the distributions in births in the wet and dry periods is statistically significant from a null hypothesis of unchanging conception rates, as tested with χ^2. The patterns appear somewhat erratic, but an underlying trend to greater births in the wet and post-harvest season in both the dry years and the wet years was observed. (This is probably due to the fact that the individual months with high conception rates lie in that part of the year, with the high conception rates not reflecting ecological factors.)

Table 7.1.1.3: Seasons of conception in wet and dry years

	n	n	Dry Season				Rains + Post-Harvest			
	wet	dry	wet		dry		wet		dry	
			n	%	n	%	n	%	n	%
$Sandveld_{1+2}$	44*	45	21	48	19	42	23	52	26	58
Boundary	40	31	24	60	14	45	16	40	17	55
Clayveld	50	35	18	36	18	51	32	64	17	49

Notes to Table 7.1.1.3:
Populations as defined in table 7.1.1.1
Dry season: J/J/A/S/O/N/; wet season and post-harvest: D/J/F/M/A/M.
Wet period: conception Mar 1975 and Feb 1982 plus Mar 1985 and Feb 1986 inclusive
Dry period: conception Mar 1982 and Feb 1985 inclusive
* the total sample size for sandveld is 89, not 90 as in Table 7.1.1.1 for this particular analysis because one of the births in Mutambe was outside of the time-frame.
The % figures refer to the percentage of either the wet or the dry period data, that fall in dry season versus the rains + post-harvest seasons. They are thus natural figures.

Discussion of Birth Seasonality

Since there are no clear seasonal patterns in either wet or dry years, and no differences between the ecological zones I therefore conclude that any (ecological) seasonal (proximal) determinants to conception are weak and show no particular difference between the zones.

An interpretation of conception peaks in particular months (Table 7.1.1.1) is that the seasonal movement of male migrant labourers is responsible. During 1986-7, 56% of the 110 men in the sample between 20 and 59 years old were semi-permanently absent or alternated between work and home.[2] Yet almost every single one of those men returned for the public holidays of Christmas/New Year and Easter/Independence Day (April). This degree of magnitude and structured pattern of male migration could certainly be well able to cause a seasonality of birth. Indeed medical staff in Zimbabwe are well aware of the phenomon, and gear up in September for what are called the 'Christmas babies' (cf. Caron *et al.* 1988:79).

A study in Kenya also found peak conceptions in December at the time of peak urban worker home leave, especially in the highland areas where migrant labour is as significant as in Zimbabwe (Ferguson, 1987:795). Harvest season conceptions were also higher than expected, and this was the second most popular time for leave (Ferguson, 1987:795). Furthermore, growing rural urban migration over the period 1979-1982 is suggested as a cause of increasing degrees of bias towards September births (Ferguson, 1987:795-6). High rainfall years strengthened the rural economy and so led to declines in urban birthrates and increases in rural birthrates due to lower migration rates; rural nutritional factors might also be involved (Ferguson, 1987:800).

Similar conclusions can be drawn from an important study in Malaysia between 1964 and 1969 that found that birth seasonalities were different between the Malay and the Chinese ethnic groups, and could be related to different 'cultural seasonalities' (Johnson *et al.* 1975). Amongst the Chinese a peak in births followed nine months after the shifting date for the Chinese New Year celebrations (1975:302-3). This was largely because:

> 'It is customary for family bread winners, often employed too far from home for frequent visits, to rejoin their families during this eight day festival' (Johnson *et al. 1975:303).*

Migrant labour mobility as the cause of conception fluctuations in this study in Mazvihwa would explain why the pattern seems independent of ecological zone. Furthermore, the lack of particular monthly peaks in conception in the boundary sample can be interpreted as a result of the fact that the men in this sample were generally not absent in such a permanent way. Most of the employed men in this sample worked locally, or in the district capital, and came home weekly or at least monthly. This is perhaps a chance effect, but probably also reflects the fact that these are the most established families in the area, and hence have been able to secure local employment patronage networks.

There is also a minor peak in conceptions in the coldest month (June), and a trough in the hottest month (November). Temperature-related fluctuations in conception rates have been recorded in many studies (eg. Stoeckel and Chowdhury, 1972), and appear to reflect a number of interacting processes (Dyson and Crook, 1981:136). These include changes in sleeping patterns (Dyson and Crook, 1981:137), sexual desire (Gupta and Lynn, 1972), and biological fertility factors (Chang *et al.* 1963:375; Chen *et al.* 1974:295; Ferguson, 1987:799). Clearly analyses must not ignore that temperature fluctuations are generally accompanied by other seasonal changes in morbidity, workload and nutritional status, and these can also influence seasonality in conceptions through behavioural and physiological factors, such as the return of women to ovulation (as first investigated by Chen *et al.* 1974): see discussion in the introduction (this Chapter).

Such temperature determined cycles would also act independent of ecological zone, as they do for diarrhoeal morbidity (Chapter Six, Section 6.1.4).

Little study has been made of ecological factors influencing birth seasonality in Africa. Although Mosher (1979) quotes little seasonality among the equatorial Baganda as evidence for his hypothesis that labour demands and food supply factors dominate birth seasonality through direct nutritional impact, in reality the data do not exist for making generalisations. In one detailed study in Tanzania, however, Bantje (1987, 1988) concluded that birth rates only demonstrated marked seasonality in areas of holoendemic malaria. Although Bantje identifies a whole range of behavioural and bio-physiological factors as playing a role, he concludes 'that behavioural rather than natural factors underlie the occurrence of birth seasonality' (1988:202). The principal process he draws attention to is physiological stress reducing fecundity, in which malaria plays the most important role as well as in reducing intercourse directly through morbidity. Yet Lockwood (1989:101-4) has questioned the degree to which malaria and associated nutritional stress is responsible for pregnancy loss and reduction of fecundity in these populations. Indeed, further up the East African coast in Kenya, where malaria is still important, the pattern is entirely different. Peak conceptions occur at the end of the rains/harvest season (Ferguson, 1987:795), whereas this is the time of lowest conceptions in coastal Tanzania (and the Gambia: Billewicz and McGregor, 1981:234). The timing of migrant labour movements cannot act as an explanation for birth seasonality in this part of Tanzania (M. Lockwood, pers. comm., 1989). Therefore changes in the frequency of intercourse independent of the effects of spousal separation appear the most likely cause, perhaps reflecting economic dimensions to gender relations (Bantje, 1988:199; Lockwood 1989:104) or other unknown factors.

7.1.2 Effect of Inter-Annual Rainfall Variability on Marriages

Hypotheses and Data for Ecological Zone Differences

The effects of rainfall variation on the agro-pastoral and other productivity of the sandveld and clayveld environments has been documented in Chapters Three and Four and in Appendix One. Clayveld productivity closely follows rainfall, and is markedly depressed during drought. However, sandveld productivity varies much less with rainfall, and is less effected by drought; furthermore high rainfall can depress yields in this zone. This means that populations on clayveld experience much greater inter-annual variability than those on the sandveld.

The population in the area studied is polygynous and bride-wealth paying. Bride-wealth currently represents several years income, so that access to women closely follows access to wealth. At any point in time there are many men who would marry, or marry further wives, if they could gain access to the capital. Cereal (during droughts) and cattle have played an important role in bridewealth payments during the colonial era, alongside money and other goods derived from remittance income. (Even remittance income is effectively more available when agricultural incomes are higher, as there are less other demands upon it.) Thus I was informed that people patterned their marriages in response to the productivity of their land; indeed that women are, in effect, exchanged between the two ecological zones, according to relative wealth which alternates in response to rainfall levels. I now test this hypothesis by examining marriage rates in each of the ecological zones during runs of high and low rainfall years.

Table 7,1,2,1 Marriage rates for wet and dry runs of years by ecological zone

		Sandveld$_1$ + Boundary (Mototi)			Sandveld$_2$ (Mutambe)			Clayveld (Mototi)		
	n years	n m'gs	n men 20-59	Rate/ 1000	n m'gs	n men 20-59	Rate/ 1000	n m'gs	n men 20-59	Rate/ 1000
Wet periods:										
1952-59	8	5	13	48	11	39	35	10	18	69
1974-81	8	15	30	63	22	99	28	18	39	58
1985	1	1	47	21	3	139	22	3	57	53
Dry periods:										
1960-73	14	14	20	50	40	60	48	14	25	40
1982-84, 1986/7	5	4	47	17	17	139	24	4	57	14

Notes to Table 7,1,2,1

n m'gs: number of marriages recorded during this period

Rate/1000: this is the marriage rate calculated per 1000 men aged 20-59 years old calculated per year.

Five of the six contrasts between sand and clayveld in runs of wet years were in the expected direction, and two are statistically significant: Mutambe sandveld v. Mototi clayveld in wet periods 1952-9 and 1974-81. (χ^2 1df. = 4,03 [p<0,05] and 7,79 [p<0,01] respectively).

Pooling the 1952-9 and 1974-81 wet runs of years and comparing the numbers of men who marry and do not marry in two sandveld populations pooled against the clayveld a statistically significant result is obtained (χ^2 6,31, 1df, p<0,02. Data from the single year, 1985, are excluded from this analysis as the sample is too small.

During dry runs of years all four sandveld marriage rates are higher than clayveld rates. The probability of all four results being in this direction is $0,5^4$ (0,0625).

In dry runs of years the paired comparisons (either singly or pooled) do not show a statistically significant difference between the zones by χ^2.

Notes on construction of Table 7.1.2.1:
The fertility-mortality recall question put to mothers was used to establish the date of the first child born into what was - or became - wedlock. This was used as the indicator of marriage. (Some women married and had children with more than one man, and the method included each of these cases.) There are problems with accepting this definition of marriage, but there is no easy way to define when a modern Shona marriage really starts (in terms of sexual relations) whilst incorporating the link to actual bridwealth payments. Illegitimate births and marriages of women to outside of the area (even if they are now in the sample through divorce or widowing) are omitted from this analysis. Illegitimacy has increased from low prior to the liberation war to extremely high; 28% of first births (in Mototi samples) since 1979 were illegitimate. (Previously pregnancy out of wedlock generally forced the couple into marriage though one third of women conceived prior to marriage pre-Independence [Cornwall 1990:55]). Illegitimate births may have been under-recorded (hence marriage over-recorded) in the Mutambe study as this was done on a single-round survey rather than a long-term study, as was the case in Mototi. Mototi sandveld and boundary population patterns show similar variation and are pooled to increase sample size.

Marriage rates per year (not the proportion of women in marriage) have been calculated by totalling the numbers of women deemed to have 'married' at each time interval (wet or dry run of years), and dividing the number of women 'taken into marriage' by the number of years, to produce rates per year. These were then calculated into rates per man using the following method. Men eligible for marriage were defined as those aged 20 to 59 years. Male marriage prior to 20 years is rare in this area. 59 years was taken as the cut-off point for marriage. Marriage of old men to young women does occur, and many men of over 50 took new wives in the study sample. However, none did over the age of 59. Many elderly men do inherit the (usually middle aged or elderly) wives of their deceased patrilineal relatives. Such 'marriages' are not relevant to this examination of the ecological fluctuations in fertility rates, and so were ignored.

An estimate of the number of men aged 20-59 in past years has been calculated from retrospectively adjusting the population pyramid of the Mototi sample. This assumes that permanent male migration into and out of the area has been negligible since 1952; indeed only three of the men have been identified to have moved into the area from a different region altogether in this time. (Low mobility is due to patrilineality in a situation of land pressure; land rights are very difficult to obtain outside of the immediate shallow patrilineal domain.). Adult male mortality (<60 years) has also been very low, though several men who would otherwise be in the household samples were killed in the liberation war in the 1970s. The 1986/7 pyramid was used for the 1980s data, and reductions of the pyramid by decades used for the 1970s, 1960s and 1950s cycles. As an accurate population pyramid was not obtained for the Mutambe sandveld sample, this population was assumed to have the same male age structure as the Mototi sandveld and boundary population pyramid. Biases derived from this method are unlikely to affect the ecological zones differentially.

Whilst Table 7.1.2.1 has examined changes in marriage rates between wet and dry runs of years, Table 7.1.2.2 simply examines whether the distribution of marriages between wet and dry years is different in the ecological zones.

Table 7.1.2.2: Distribution of marriages in dry and wet runs of years

	Number of men marrying in wet periods	Number of men marrying in dry periods	Total
	n years 16	n years 14	
Sandveld+Boundary	53	54	107
Clayveld	31	14	45

Notes to Table 7.1.2.2:
1982-7 data has not been included as marriage rates have changed dramatically since independence; see Table 7.1.2.1. This is discussed in Chapter Nine.

The distribution of marriages is statistically significantly different between the zones (χ^2 4.75, 1df, $p<0.05$).

There are sixteen wet period years (1952-9 plus 1974-81) and fourteen dry period years (1960-74). However, the analysis contrasts the ratios of marriage distributions between the zones and so this does not matter.

Table 7.1.2.2 shows that clayveld marriages are much more frequent in the wet runs of years than in the dry years, whilst there is little difference in marriage rates with rainfall in the sandveld populations. Table 7.1.2.1 provides the detailed presentation of actual marriage rates for the wet and dry runs of years. During the wet runs of years the number of marriages by clayveld men is higher than that of the men in sandveld. Furthermore, during the dry runs of years marriages are more frequent in sandveld than in clayveld. In contrast to clayveld, sandveld marriage rates are similar in wet and dry runs of years, indeed overall dry year rates are slightly higher than those in wet years.

Concluding Discussion on Inter-Annual Variations in Marriage

This analysis has confirmed the hypothesis that marriage rates are tied to the contrasting productivity dynamics of the two environments. During wet runs of years clayveld men marry more frequently than those of sandveld, whilst the reverse is apparently the case during dry years. Men have been highly conscious of their struggle with or against the runs of high or low rainfall, to accumulate sufficient wealth for marriage. Up until 1947 pledging of young girls in marriage (**kuzvarira**) in exchange for food between these zones was a major form of marriage, even though colonial officials worked extremely hard to stop it (eg. Cripps, 1931; see Appendix Two).

Since independence marriage rates have declined markedly (Chapter Eight). There is also a suggestion that 1970s rates are less different between ecological zones than those of the 1950s and 1960s. This might suggest a relative decline in the contribution of rural production to bridewealth. However, there is a return to great contrast in marriage rates in the 1980s, and it should be noted that wage labour has played an important role in meeting bridewealth requirements throughout the colonial period.

7.1.3 Inter-annual variation in birth interval and birth rate

Introduction

This section examines whether there are differences in human fertility between the ecological zones in wet and dry runs of years. Clayveld fertility is predicted to be elevated in wet runs of years, whilst sandveld fertility be elevated in dry runs of years. This could have either a bio-physiological or an ecological-economic causal basis (or perhaps both). The former is predicated on relationships between nutrition and fertility (see introduction). The latter include the effect of changing levels of male-outmigration consequent on rainfall-dependent agricultural productivity (cf. Ferguson, 1987:800 for Kenya), and possibly even deliberate strategies to avoid births at times of greater ecological stress. These effects might be counter-balanced to a small extent by the fact that infant mortality is highest at the same times of ecological stress (Section 7.2.1), and birth intervals are shorter after an infant death, thereby elevating birth rate at times of stress. However, prior to any detailed discussion it should be noted that no such fertility patterns are produced in this data.

Differences in birth interval in wet and dry runs of years

Data in Table 7.1.3.1 suggest that mean birth interval changes little between wet and dry runs of years in both sandveld and clayveld populations. In all three populations there is an indication of marginally shorter birth interval during the dry period 1960-73. The hypothesis that birth interval would lengthen in clayveld is therefore not supported. It is not known whether this is a secular socio-economic trend, a measurement artefact, or a reflection of unknown ecological factors acting on all three ecological zones.

Birth intervals since 1980 (independence) are somewhat longer than in the 1950-79 period. This is discussed in some detail in Chapter Nine.

Table 7.1.3.1: Mean Birth Intervals (Years) in Wet and Dry Runs of Years

	Mototi Sandveld and Boundary			Mutambe Sandveld			Mototi Clayveld		
	n	mean	σn-1	n	mean	σn-1	n	mean	σn-1
Wet Years									
1952-9	24	2.50	1.14	38	2.71	1.58	38	2.82	1.80
1974-81	64	2.42	1.73	125	2.86	2.00	75	2.40	0.92
1985	10	3.00	1.05	19	2.63	1.07	2	2.00	-
Dry Years									
1960-73	59	2.37	0.82	162	2.65	1.93	124	2.40	1.12
1982-4,86-7	47	2.66	1.20	67	2.90	1.68	43	2.56	0.88

Notes to Table 7.1.3.1
The birth intervals are only measured in whole years (eg. where there was a birth in 1966 after a previous birth in 1963 an interval of three years is recorded).

Birth intervals assigned to runs of years are those preceding conceptions during those runs. Gestation has to be assumed as a whole year, as exact birth months are not known.

Effects of Wet and Dry Runs of Years on General Fertility Rate

Table 7.1.3.2 examines the General Fertility Rate (GFR) for the three populations. Whilst it had been predicted that the GFR would be higher in the sandveld populations in the dry run of years, and lower in the population on clayveld, in fact it was notably higher in all three populations in the 1960-73 dry period. As Total Completed Fertility is highest in clayveld (see Section 7.1.4), the GFR are always higher in this zone than in sandveld.

Table 7.1.3.2: General Fertility Rates in runs of years with different rainfall

	Kototi Sandveld and Boundary			Mutambe Sandveld			Kototi Clayveld		
	n born	n w'n	rate/ 1000	n born	n w'n	rate/ 1000	n born	n w'n	rate/ 1000
Wet Years									
1952-9	29	124	233	47*	284	166	50	169	296
1974-81	85	331	257	145	668	217	99	355	279
Dry Years									
1960-73	78	289	270	200	668	277	138	415	332
Total fertility		7.7			6.9			9.3	

Notes to Table 7,1,3,2
n w'n is the number of women aged between 15 and 44 years multiplied by the number of years in that time interval,

The rate/1000 is thus the 'General Fertility Rate' (GFR)

The 'completed fertility' levels calculated from the general fertility rate correspond reasonably closely to those reported in Section 7,1,4, where the differences apparent between the zones are investigated,

* The number of children born to Mutambe women in 1952-9 seems to be underestimated because of the under-recording of infant mortality (see Section 7,2,1); estimating real infant mortality rates to be around 200/1000 at that time, fertility should be 18% higher, This produces a GFR of 196/1000, closer to the expected figure, but still low suggesting that even some live births have gone under-recorded in this study at that time,

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Concluding Discussion

The ecological zones apparently show no differences in their fertility-response to runs of wet and dry years: all three populations show an increase in fertility during drought, like those in the Gambia (Billewicz and McGregor, 1981:233). Declines in fertility during famine have come to be expected, but these presumably result as much from social disruption as they do reduced fecundity and elevated pregnancy wastage. It must therefore be stressed that in this Zimbabwe population sample these dry years have not precipitated 'famine' - with its qualitatively different socio-economic and biological conditions - but simply a period of dearth particularly marked for those living on clayveld. The 'environmental stress' hypotheses concerning relations between ecological stress and fertility have therefore not been confirmed. This raises theoretical and empirical questions about whether this result is just a feature of the study area, lack of extreme circumstance or data quality, or has more general applicability.

7.1.4 Differences in Human Fertility Between Ecological Zones

Introduction

This section examines differences in fertility between the populations in the two ecological zones. As has been alluded to in Section 7.1.2, The General Fertility Rate is higher in clayveld than sandveld populations. The greater clayveld variability in both productivity (Chapters Three and Four), and under five mortality (Chapter Seven, Section 7.2), would be predicted by theoretical biology to lead to a strategy of higher fertility than on the sandveld.[3] Such differences in fertility could reflect deliberate strategies, but these were not articulated to me as such by the populations concerned.

Most of the difference in completed fertility between the populations is accounted for by a shorter reproductive life reported by sandveld women, though long birth intervals may account for about a quarter of the difference. In the absence of other marked physiological or socio-economic differences between zones, the possibility of the cause being greater polygyny on the sandveld is then examined.

Numbers of Children Born Alive to Women of Different Ages

The number of births to women of different age-groups are presented in Table 7.1.4.1. The small sample sizes clearly limit analysis, and there were several other problems faced discussed below.

Problems with the analysis in Table 7.1.4.1
Determining accurate ages for women was difficult; inevitably local people, and ourselves, used assumptions about fertility in order to assess age. Women were generally assumed by people and ourselves to start giving birth around twenty years, which is quite late by African standards. This figure was also found by Cornwall in more detailed examination of a sub-sample of these women, when the figure was 19-20 years (1990:56). The mean age of first birth in the 1982 census was 21.2 years (CSO, 1985), and is currently around 23-24 years of age (see Table 7.1.4.1) suggesting that women are starting to give birth later in recent years (see Chapter Nine). It is possible that ages of old women were distorted by this however, since in the more distant past women started giving birth younger as pregnancy is said to have usually followed within a few years of menarche. Available evidence supports this. Shaul (1955c and 1955d) reports from the 1948 and 1953 census data that menarche was at 15 and 15.3 years (see also Burrell *et al*, 1961, and Frere, 1971:23, for similar figures for South Africa); mode age of first births in a Harari hospital in 1954 was eighteen years (Ross, 1955), despite the fact that this was presumably handling more elite women. However, the fact that completed fertility tends to be higher in the 45 to 49 age group than the 40 to 44 years old group, and to not change systematically after that does suggest that approximately correct ages were being assigned, because this suggests that the final births were occurring between 45 and 50 years of age. (According to Frere, 1971:21), the mean age of menopause in South African Black women was 50.7 years; whilst that in twenty women in this sample was 51.7 years [Cornwall, 1990].)

Only women who had been resident in the same ecological zone during their reproductive lives were included, and fertility in cases of divorce was excluded. Lower fertility may be a feature of divorced women, or of women who have tended to migrate around a lot with periods in towns. The single case of a woman who died whilst still fertile was included, however. Cases of older women without issue were included, but may perhaps be underestimated as such women often leave the rural areas. None of these effects may be expected to affect zones differentially, though they will lead to generally higher fertility being recorded in the sample than can be expected for the whole population.

In Mutambe the research was a single round survey and I could not rely on investigative techniques used in Mototi. Recorded fertility has been shown to increase with the length and depth of the investigation (Early, 1985). Indeed, it appears from the infant and child mortality rates for the pre-1960, that in Mutambe ? children who did not survive were being omitted entirely from the fertility record (see Section 7.2). The effect of this will be to depress apparent total fertility rates in older women in this particular sub-sample. Furthermore, in Mutambe there was no independent demographic work to establish the number of women over fifteen but not yet married. Therefore the number of children born alive for women of 15 to 25 years of age is omitted in Table 7.1.4.1. for Mutambe.

The proportions of women in each age-group vary because of the historical carry-over effects of the marriage rate differences of wet and dry periods (see Section 7.1.3). For example, at the time of survey (1987) after several years of drought and hence reduced marriage rates for clayveld, there were no women presently under twenty years with children in this zone.

A final problem is that total fertility has not been historically constant. There is evidence from birth interval data in the 1980s that for birth orders above 5th birth, birth interval is notably longer post-1980 (Chapter Nine); this presumably reflects greater desire and ability to reduce family size since Independence. Secondly in this analysis of total fertility by age women of over 50 years in sandveld populations reported a mean of only about six births, whereas women in these populations between 40 and 49 years reported about eight births. National data also suggest that fertility has been increasing until recently in Zimbabwe, from around six to seven live births (see notes to Table 7.1.4.1. and Chapter Nine). Such changes, if indeed the case, reduce the validity of using current fertility by age to estimate fertility rates. (An alternative explanation for these differences is that older women gave us less complete birth histories; this seems unlikely to be sufficient explanation as mortality rates for children under five (250/1000) for the 1930s to 1940s for these women appear approximately correct; live children were not missed out due to the extensive family-tree information available.)

Table 7.1.4.1 Age Specific Fertility Rates by Ecological Zones (Average Number of Children Born Alive by Age of Mother)

Age Women	Mototi S'veld/Bound			Mutambe Sandveld			Mototi Clayveld		
	n wom	mean chn.	σn-1	n wom	mean chn.	σn-1	n wom	mean chn.	σn-1
15 to 19	9	0.01	0.33		*		26	0	-
20 to 24	12	0.1	0.29		*		14	0.9	1.03
25 to 29	19	3.3	1.00	16	2.8	1.44	13	2.9	1.63
30 to 34	6	4.8	1.72	18	4.5	2.18	7	4.1	2.41
35 to 39	5	6.6	1.52	15	5.9	2.10	6	4.8	3.19
40 to 44	3	4.7	4.04	9	8.0	2.24	8	8.9	1.46
45 to 49	6	9.2	4.26	12	8.1	2.19	5	8.6	0.89
50 to 74	9	6.3	3.12	23	6.0	2.90	16	9.4	2.28
Tot Women	69			107			95		
Women Aged 40-49	9	7.7	4.53	21	8.1	2.16	13	8.8	1.24

Notes to Table 7.1.4.1
* In the case of women under twenty four years of age in the Mutambe sample, only women who had children were enumerated, so the data could not be converted into population rates.

The completed fertility of women over fifty was greater in clayveld than sandveld. Mototi sandveld plus boundary versus Mototi clayveld; and between Mutambe sandveld versus Mototi clayveld, produced values of t= 2.74; 24df; p<0.01 and t= 4.5; 38df; p<0.005, respectively.

Amongst women aged 40-49 years the fertility differentials are less marked and not significant. Mototi clayveld versus Mototi sandveld plus boundary and Mototi clayveld versus Mutambe sandveld gave values of t= 0.81; 21df; n.s. and t= 1.06; 33df; p<0.2 only. Pooled sandveld versus clayveld samples give t= 0.96; 42df; p<0.2.

The following comparative fertility estimates are available in the literature:

Time Period	Source	N Live Births	Reference
Early colonial era	Native Commissioner ests.	6	Beach (1988)
1953	17 District sample census	5.7	Shaul (1955d)
1969	National Census	6.9	C.S.O. (1985)
1982	National Census	7.2	C.S.O. (1985)

The number of live births for women over fifty years old was fifty percent greater in clayveld than sandveld, and the difference highly significant statistically. However, current total fertility of women presently at the ends of their reproductive lives (aged 40-49) do not show such great differences. With younger women there are no systematic differences between number of live births in each age category between the ecological zones.

Birth Intervals and Length of Reproductive Life: relative contribution to fertility differences between the zones

The extent to which birth interval and the length of reproductive life are responsible for the observed differences in fertility was assessed by calculating the differences in these variables for the three populations. Generally speaking birth interval has been found to be the critical variable controlling completed fertility in African populations (Hill, 1985:57-8).

Methods used and the problems involved

1. Mean birth intervals for those women considered to have completed their reproductive lives were calculated. Women were considered to have completed if they had not given birth since 1982 (end 1987 timeline); only 4% of recorded birth intervals were longer than six years. Nearly all the women identified were clearly post-menopausal, though this could not be ascertained definitively. Age categories were not used to ensure against any bias resulting from avoiding women who might cease giving birth relatively young (as is shown to the case in sandveld below). Birth intervals were derived from the number of years between the first and last birth, divided by the number of births (excluding first birth).

2. Length of reproductive activity was calculated as the number of years between first conception (taken, for simplicity, as one year before year of first birth) and last birth. Divorced women, infertile women, and those not permanently living in the region were excluded. The woman who died was included, however. The method does not establish whether the differences in lengths are caused by earlier onset (puberty and/or marriage) or later ending. It is possible that some of the differences observed in Mutambe sandveld, the single round survey, are due to condensing of the birth histories. However, this is unlikely to have resulted in the degree of difference observed, and cannot explain the same, though weaker, result with Mototi sandveld.

Table 7.1.4.2 Mean Birth Intervals of Women with Completed Fertility by Ecological Zone

Mototi S'veld/Bound n births	Mototi S'veld/Bound mean interval	Mutambe Sandveld n births	Mutambe Sandveld mean interval	Mototi Clayveld n births	Mototi Clayveld mean interval
94	2.78	208	2.96	190	2.58

Table 7.1.4.2 shows that birth interval is a little shorter in the clayveld than the sandveld populations, and that this is only partially responsible for elevated fertility of the clayveld. The shorter birth intervals produce between 7 and 13% higher fertility on clayveld than the Mototi and Mutambe sandveld populations respectively.

Table 7.1.4.3 Lengths of Fertility in Women with Completed Fertility by Ecological Zone

Mototi S'veld/Bound			Mutambe Sandveld			Mototi Clayveld		
n wom	mean years	σn-1	n wom	mean years	σn-1	n wom	mean years	σn-1
17	16.3	6.74	44	14.3	8.07	26	19.8	7.35

Notes to Table 7.1.4.3
The length of fertility is longer in clayveld than sandveld. Tests of Mototi clayveld and Mototi sandveld plus boundary, and between Mototi clayveld and Mutambe sandveld gave t values of t= 1.54; 42df; p<0.1 and t=3.06; 69df; p<0.005, respectively. A test of combined Mototi and Mutambe sandveld versus Mototi clayveld gave a result t= 2.4; 85df; p<0.01.

Cornwall (1990;57) using mostly data from clayveld women, obtained a somewhat longer fertility period, 24.9 years (n=25 sd. 1.28), for reasons unknown.

Mototi clayveld women had a longer period of child-bearing 'fertility' (between first conception and last birth) than did the sandveld women; clayveld length of fertility is around 20 to 40% higher than sandveld due to this factor (Table 7.1.4.3). It is quite an unusual pattern in rural Africa to find that the number of years fertile contributes more to differential fertility than does birth interval. It may reflect sterility associated with venereal disease, but even this tends to mainly affect birth intervals (Retel-Laurentin and Benoit, 1976:291-2).

Although the result might possibly represent earlier menarche/marriage in clayveld populations, this is unlikely. It is the sandveld people that have the reputation for marrying very young women, and at the time these marriages occurred child pledging marriages were still fairly common, and were more important in sandveld (see Appendix Two). Even if there were differences in in the age of menarche (there is no reason to think that there might be), it would be physiologically extraordinary if these were greater than a single year. Therefore the bulk of the difference in fertility must be an earlier decision to stop having children (for consideration of fertility control, see Chapter Nine), or menopause at a very early age (sandveld women were reporting only fifteen years of child bearing). Early menopause in a large proportion of the population seems unlikely. Studies of African populations in South Africa suggested that menopause may be as late as 50.7 years on average (Frere, 1971); and the only data for Zimbabwe suggest a similar result (Cornwall 1990). However, a recent study of premature menopause in Zimbabwe (Chimbira and Kasule, 1987), found that it was commonly associated with the use of depo provera (under the previous regime: see Chapter Nine), and indigenous medicines (muti). Some of these medicinal plants are specifically prescribed to end fertility. Other factors included genetic, auto-immunological and other dysfunctions (Chimbira and Kasule, 1987).[4] .

Greater polygyny by elderly men on sandveld is not responsible for the differences in fertility

Polygyny is much more common on sandveld and boundary populations in this particular study area. Local people state that this is principally because sandveld in Mazvihwa is mainly inhabited by the chiefly lineage who put a higher premium on polygyny as one of the 'traditional' values they maintain. Outsider lineages also practise more polygyny on sandveld, especially those who are long established. The other main reason given for polygyny in this environment is the need for large families to ensure economies of scale in guarding against marauding baboons.

There has been considerable research by demographers into the effects of polygyny on female reproductive performance. More recent reviews have shown that the majority of previous studies have been inadequately controlled, and that a range of relationships exist depending partly upon the social and biological relationships of men and women in the marriage system (Borgerhoff-Mulder, 1989). Most studies have reported that wives in polygynous unions show depressed fertility (George, 1981; Ban and Mineau, 1986; Garenne and van de Walle, 1989), though no overall relationship was found in a thorough study of the Kipsigis in Kenya (Borgerhoff-Mulder, 1989). Lower fecundity of old men, rather than reduced frequency of intercourse, may be responsible (Garenne and van de Walle, 1989:282-3).[5]

Higher levels of polygyny could therefore be the explanation for lower fertility of sandveld women, as about half of the wives in polygynous unions in this sandveld sample are more than fifteen years younger than their husbands. The effect of polygyny is therefore tested (Table 7.1.4.4) for the small sample of marriages in my data set for which there is adequate information to document their stability.

The completed fertility of women in continuous polygynous unions was not lower than those in monogamous unions; indeed the opposite pattern was observed, though it is not statistically significant (Table 7.1.4.4).

Table 7.1.4.4 Completed Fertility of Women from Monogamous and Polygamous Unions

	Women over Forty Years			Women over Fifty Years		
	n women	mean births	σ_{n-1}	n women	mean births	σ_{n-1}
Monogamous	7	6.71	5.14	3	6.00	6.00
Polygamous	9	7.44	1.70	6	6.50	1.05

To complement this analysis, male reproductive potential within a polygamous union was examined, in the context of only elderly men generally being sufficiently wealthy to marry many wives. The effect of paternal age is minimal. Where the father was over fifty before the polygynously married wife completed giving birth, the average fertility of those wives was above average (8.7 live births; n=7), rather than below, as would have been predicted. However, where there was greater than a fifteen year age difference between a woman and her husband, her fertility was just slightly below average (5.75 live births, n=4). (It should be noted that it is rumoured that many children in polygynous unions involving old men are sired by other men.)

Discussion

There is a marked human fertility differential between the ecological zones, especially amongst the oldest women. The women in the more variable clayveld environment have fertility perhaps as much as one third higher as those dwelling in the sandveld. However, the difference is less marked in women of 40-49 years of ages, and may even be non-existant below the age of forty years. The difference in number of live births is found mainly to result from longer periods of fertility in clayveld women, so the lack of differences in younger women is simply a function of their not yet expressing whether or not they will express different fertility by stopping having children at the same mean age.

Of twenty-six women responding individually to questions about the increasing need to regulate human fertility, more of the sandveld and boundary population respondents were in favour of regulation than were those from clayveld, though the result was not statistically significant. It can be noted that in the limited interviews conducted women denied that there were systematic differences in human fertility between the zones, and those interviewed appeared astonished at the suggestion that there might be differences in reproductive strategies. Nevertheless, a plausible explanation can be found in the greater household orientation of the originally migrant clayveld households (Chapter Eight), and hence the desire/requirement for greater family labour, as this is not so well mobilised through patrilineal networks (see Chapter Ten).

Investigation of sandveld marriages showed that polygyny and marriage to old men were not what was responsible for depressing sandveld fertility. Indeed, from the national perspective it is not that sandveld fertility is low, rather that clayveld fertility is very high. (The mean number of children ever born in the 1982 census is 7.2 for women aged 45-49: C.S.O. 1985:148; similar to that recorded for sandveld in this study, where all women on sandveld and boundary combined over forty years of age had reported an average of 6.99/live births.)

7.1.5 Conclusions to Section 7.1

The examination of the interaction between ecological dynamics and fertility suggested that the relationships are much weaker than with other variables analysed in this thesis. Seasonal variations in birth rates appear to reflect labour migration cycles, whilst inter-annual fluctuations are small and have no identifiable ecological determinants. This weakness in ecological determinants may reflect the high degree of fertility management achieved by this population employing 'indigenous' as well as Western contraception (see Chapter Nine, Section 9.2). Marriage rates, on the other hand, do indeed reflect inter-annual fluctuations in rainfall, resulting from the effects that this has on agricultural productivity (Chapters Three and Four), and hence ability to pay bridewealth. Overall human fertility is markedly higher in clayveld than sandveld, as would be predicted on the basis of its higher variability in productivity and mortality. However, a more likely explanation is differences in reproductive strategy due to historically-shaped contrasting lineage relations (see Chapter Eight).

Section 7.2 Mortality

Introduction

This section examines mortality in the two ecological zones. Section 7.2.1 briefly examines the information on reported 'cause of death', so as to inform future discussion. Section 7.2.2 describes evidence for contrasting patterns of inter-annual mortality between the ecological zones. This tests the prediction derived from literature and the conclusions of Chapters Five (Nutrition) and Six (Morbidity), that clayveld mortality is elevated in drought, whilst sandveld mortality is elevated in the wet years. Nutritional status, birthweight and changing levels of morbidity are then evaluated as causal factors, using existing empirical and theoretical studies, so as to link the data in Chapters Five and Six with this important observation.

It must be noted that the data available on mortality that are analysed in this section do suffer even greater constraints of sample size than material presented in previous chapters.

Unfortunately seasonality of death data were not collected so as to test whether the contrasting seasonality of morbidity (Chapter Six) and nutritional status (Chapter Five) are reflected in the seasonal pattern of mortality. The hypothesis seems promising, given that existing data, though limited, do suggest that in 'moist' savannah areas (which functionally resemble sandveld) there is a wet season mortality increase (McGregor *et al.*, 1970:64;[6] Cantrelle and Leridon, 1971:517-8), whilst in the drier areas there is evidence for a hot dry season peak (Crook and Dyson, 1981:145).[7]

7.2.1
Differences in the causes of deaths between ecological zones

This section examines data on the causes of death as stated by mothers in the fertility-history question. This can provide a foundation for the discussion of mortality differences between the ecological zones.

It is important to note that only known causes of death are reported in Table 7.2.1.1. Some five percent of 'causes' were unassigned due to failure to ask the mother. Additionally, 21% of deaths under one years' old could not be (or anyway were not) assigned by the mothers, and the corresponding figure for 1-5 year olds was 13%. Much of the excess unassigned infant mortality presumably reflects neonate deaths of complex aetiology.

Stoughton (1975:185) obtained a very similar figure for such deaths of 18% in Bikita, Southern Zimbabwe. Studies of under four mortality in eastern Kenya suggested that these deaths contribute to around 30% of overall mortality.[8] It should be noted that tetanus was not reported by Stoughton or in my study, except for one possible case. Among the Baba-Oule of Burkina Faso, tetanus was responsible for 35% of under-one deaths. Lack of tetanus recorded in the Zimbabwe study may reflect two factors: firstly 'tetanus' may not be recognized as a cultural category in this population (not investigated, but never articulated to me spontaneously), and secondly, tetanus immunization may mean that tetanus is now not very common (see Chapter Eight), though this cannot explain its absence in the earlier records. It may be that tetanus is quite common and is subsumed within unknown neonate mortality. It can be noted, however, that in several years of careful clinical observation in Eastern Kenya no single tetanus-death was recorded (Omondi-Odhiambo *et al.*, 1984:221).[9]

Table 7.2.1.1 Known Causes of Death of Under Fives by Ecological Zone
(All Deaths Reported Since 1940)

	Mutambe Sands and Mototi Sands plus Mototi Boundary								Mototi Clays							
	<1yr			1-5yrs			total		<1yr			1-5yrs			total	
Cause	n	$\%_1$	$\%_2$	n	$\%_1$	$\%_2$	n_2	$\%_2$	n	$\%_1$	$\%_2$	n	$\%_1$	$\%_2$	n_2	$\%_2$
Total deaths	(n= 37)			(n= 15)			(n=52)		(n= 33)			(n= 19)			(n=52)	
Gastro-intest	24	65	65	7	47	53	32	62	20	61	67	10	53	60	34	65
Pulmonary	4	11	11	2	13	20	7	13	1	3	15	2	11	15	8	15
Measles	5	14	14	5	33	33	10	19	0	0	0	1	5	5	1	2
Fevers	1	3	3	0	0	0	1	2	3	9	15	1	5	10	7	13
Small pox	1	3	3	0	0	0	1	2	1	3	3	1	5	5	2	4
Other	2	5	5	0	0	0	2	4	4	12	12	2	11	11	6	12
Multiple Causes																
Gast + pulm	0	0	-	1	7	-	-	-	2	6	-	1	5	-	-	-
Gast + fever	0	0	-	0	0	-	-	-	0	0	-	1	5	-	-	-
Pulm + fever	0	0	-	0	0	-	-	-	2	6	-	0	0	-	-	-

Notes to Table 7.2.1.1
$\%_1$ is the percentage of deaths of infants or children of that age caused by this category of disease considered alone

$\%_2$ is the percentage of deaths from this category of disease including where the disease is part of multiple category causation. The percentages in this category thus may add up to more than 100

n_2 refers to the number of deaths from that disease category, including deaths from multiple category causation; thus the total adds up to more than the number of deaths recorded.

Information concerning the establishment of disease categories are found in the Methods Chapter. 'Gastro-int' includes diarrhoea, vomiting, and depressed fontanelle/dehydration.

Differences between zones, statistical treatments:
1. On sandveld there was much more death through measles recorded; this result is significant at $p<<0.01$ ($\chi^2 = 8.24$; 1df).
2. On clayveld there were higher rates of death from "fevers"; $\chi^2 = 3.04$ at 1 df, so this is almost significant at $p<0.1$ >0.05.

Broadly similar results were obtained from both the sandveld and clayveld zones. In both ecological systems diarrhoea and related symptoms dominate cause of death, and for the cases where data is available, it killed over two thirds of infants (<1 year) and over half the children (1-5 year olds), whose cause of death was stated. The result parallels other surveys of this kind in savannah Africa, and Ministry of Health data for Zimbabwe (UNICEF 1985:13-5) except for registered infant mortality where respiratory infection was reported more frequent than diarrhea. A study in nearby Bikita in 1972 reported 41% of deaths as a result of gastro-enteritis, 14% from pneumonia and 10% from measles (Stoughton, 1975:185). Likewise, gastro-enteritis, pneumonia and measles were also the three most important causes of 0-4 year old deaths in Eastern Kenya (Omondi-Odhiambo *et al.* 1984:220).

The two main differences between the sandveld and clayveld results, were that 'fevers' were more important in the clayveld populations, and measles was more important in the sandveld population.

'Fever'

If deaths from 'fever' represent mainly deaths from malaria then the higher mortality from this in clayveld is surprising. In sandveld the effect of the dambo swamps is to provide surface water for the breeding of mosquitoes during a substantial part of the rainy seas, and mosquitoes can be very troublesome in this zone. In contrast in clayveld (in 'average' and 'drought' years), mosquitoes are only found very close to the rivers: they rarely reach the homes which are set back from the rivers due to government settlement regulations. Only in wet years were mosquitoes commonly encountered in homes in clayveld, and in such a year (1988) I did indeed contract malaria, whilst living in clayveld. During this wet year the Zimbabwe press reported much more malaria than usual in the whole region. Clayveld malarial mortality could only be higher than that of sandveld if clayveld children are more susceptible to malaria because their immune-system is exposed only in the high rainfall years. Indeed, all five infant deaths on clayveld were indeed observed to be in such wet years (though the two child deaths were in droughts).

There is some uncertainty, however, about the degree to which malaria is responsible for fevers in this region of Zimbabwe. Health workers, past and present, find that malarial treatment is remarkably effective, whilst laboratory assessments rarely confirm malaria (Dr M. Hahn, then Matibi Mission, pers. comm. 1986). The official rate of test positives is only 227/100,000 (Loewenson and Sanders, 1988:148); between 1972 and 1981 the incidence of malaria in this part of Zimbabwe was said to be only 2% per annum (Taylor and Mutambu, 1986:14). The neighbouring sandveld clinics, Murowa and Mutambe, treated significant amounts of what they viewed as malaria during the year I checked their records (1987); 13 cases of under 5 year olds, and 162 over 5 year olds. This represents an incidence of around 3%, and ignores frequent self-treatment with purchased anti-malarials, church or herbal medicines, and also much untreated morbidity. Nearly all the reported malaria was during and just after the rainy season (cf. Gelfand, 1983:234; and Taylor and Mutambu, 1986:17-8 reporting a late rains/post rains peak).

If malaria is not in fact the major contributor to fevers, then it is useful to try to identify which other diseases might be responsible. Typhoid often presents with fever rather than (or together with) diarrhoea, and has been noted to be often confused with malaria in Zimbabwe; to separate them properly requires blood tests (Kagwa-Nyanzi, 1971; Gelfand, 1983:234). Typhoid is noted by the health authorities as common among people on the clayveld using the Lundi river for water (Dr Ndlovhu, pers comm. 1987); it would be expected to be less common in sandveld, where the water supplies are predominantly dambo wells (Chapter Six, Section 6.3.1). Therefore, it may be typhoid rather than malaria that explains the higher 'fever' mortality in clayveld.

Measles

Measles is a much more important cause of death in sandveld than in clayveld. This might reflect either susceptibility or exposure. Measles infection appears to be most common in opposite seasons in the two ecological zones (Chapter Six, Section 6.1.7), and seasons of infection coincide with those of greatest nutritional stress (Chapter Five, Section 5.2). Therefore, although there is some debate about the significance of poor nutritional status to case fatality in measles (see Chapter Six, Section 6.4), whether there is a relationship or not, the seasonal difference cannot explain the greater level of measles mortality in sandveld. Settlement patterns at Mototi are somewhat different between the sandveld and clayveld. The sandveld population lives in more scattered but larger households under a slightly lower population density. It may be that crowding in these large households is responsible for higher case fatality, as reported in a study in Guinea Bissau (Aaby *et al.* 1984). Settlement patterns may also be responsible for differences in exposure. However, it is ulikely that there are differences in immunization and treatment between ecological zones.

7.2.2 Inter-annual variability in rainfall and mortality rates

Introduction

There has been very little research on inter-annual variations in mortality rates in African savannah populations; apart from estimates of 'famine' mortality rates in droughts in refugee camps. In this introduction I review this material, to establish the hypotheses tested with Mazvihwan data.

I open the review of empirical data by establishing that existing evidence suggests that in moist savannahs drought actually reduces mortality, probably by improving disease environment, without making a marked impact upon food supply. This relationship is presumably different in the semi-arid savannahs, since drought will reduce food supply and worsen disease environment in this zone (cf. Chapters Three, Four and Six). Yet research in this semi-arid zone has been dominated by investigation of periods when droughts lead to such disruptions of food supply that 'famine' results, which introduce some novel factors, particularly the effect of population displacement and concentration in settlements. In those cases where substantially elevated mortality does occur it typically reflects both disease environment and nutritional factors, though the extent that each contributes remains uncertain, and clearly varies. Demographic studies of the African famines have concentrated upon child mortality, but this is partly a methodological artefact of not investigating infant mortality (see General Methods, footnote 18).

Next I review prospective studies of sample populations that elucidate the relationship between anthropometric status and vitamin deficiencies and risk of mortality in children. Finally I consider the interaction of birthweight and neonatal mortality rate, and how these are influenced by famine. This latter issue provides a central theoretical reference, as it may be the main explanation for the patterns of reversed mortality levels between ecological zones that I find in my data for Zimbabwe, which are then presented, whereby mortality increases in drought in clayveld, and in wet years in sandveld. In contrast, child anthropometric status in this area appears not to decline sufficiently on clayveld to lead increased mortality driven by disease susceptibility; and nor does sandveld anthropometric status worsen sufficiently in wet years to have the reverse effect. Drought or high rainfall in this area of Zimbabwe is not associated with distress-migration and hence increased mortality due to disease-exposure.

Moist Savannahs

In the moist savannah regions drought may actually reduces mortality, in the same way that it improves anthropometric status (Chapter Five) and reduces morbidity (Chapter Six). In The Gambia, Billewicz and McGregor (1981:225) ascribed the lower mortality of the 1971-5 period compared to the 1960s as possibly having 'been the result of reduction in endemic communicable disease patterns, particularly those associated with insect vectors, caused by the Sahelian drought'. Likewise, lowering mortality in 1966-71 among the Bob-Oule of western Burkino Faso may actually have been due to lower rainfall rather than the marginal expansion in health services that it was attributed to by Retel-Laurentin and Benoit (1976:280-1).

Drought and Famine in Semi-Arid Savannah Areas

In the drought-vulnerable semi-arid and arid savannahs, dry years (and especially a series of dry or poorly distributed rainfall years) can lead to declining food access amongst certain population sectors and thence to dearth and what is called famine.[10] Mortality in droughts must therefore be discussed together with material on 'famines'.

There is evidence that each of the great African famines in the last two decades has elevated mortality, though the extent and exact causes are still open to speculation. Although epidemiologists and scholars of famine have long been agreed that increased mortality results from nutritional deprivation <u>in combination with</u> increased exposure to disease (see, for example, Bang, 1979), the exact contibution of each appears variable and uncertain. For example, Watkins and Menken (1985:649-50) have concluded:

> 'famine seems to be associated with an increase in deaths from a number of infectious diseases . . . Some of the increase in infectious disease may be due to increased susceptibility that is thought to accompany malnutrition and some may be due to the peculiar conditions that accompany scarcity, for example, a breakdown of systems of water supply and waste

> disposal, an increase in the number of vagrants, or the crowding and dismal conditions of the refugee camps.'

And in the view of Caldwell (1984:4; with reference to Dubois, 1974:9) it is hardly possible to discern the contribution of nutrition and elevated exposure, given the methods and data available:

> 'Most additional deaths could not be ascribed directly to starvation but were rather the products of a higher level of deaths from infectious and other diseases than would have occurred if the population had been better nourished. In these circumstances, neither individual families nor demographic field researchers could identify which deaths would not have occurred but for the famine'

It is important to establish that there are at least three dimensions to the ecological contribution to changed mortality in drought induced famine. First there is the effect on ecological productivity and hence food supply; this is linked to declining anthropometric status and thus increased disease susceptibility. Second, there is a direct effect of drought on disease environment (eg. on populations of insect vectors or amount of dust). Third drought (eg. water supply failure) and famine (entitlement failure/new survival strategies) lead to migration which has indirect effects on disease environment. Sheers and Lusty (1987:785) have postulated four factors determining the extent of contribution of migration to increases in disease exposure and hence to elevated famine mortality:

1. Those determining the form and extent of distress-migrancy and thus concentration into camps and shelters; and, furthermore, how different are the resulting patterns of person-person contact, and levels of sanitation and health care from the previous situation of the population.

2. The degree of nutritional stress experienced as a result of changes in food intake, energy expenditure and other factors determining nutitional state; and hence vulnerability to the poor disease environment of the camps.

3. The extent of concomittant breakdown of existing health care and disease control systems in the source areas from which the displaced come, where they crowd together (eg. the decline in measles vaccination in the months or years prior to displacement).

4. movements of displaced populations into new ecological zones with novel disease risks (eg. of highland Ethiopians into malarial lowland).

However, the paucity of existing data in Africa mean that analysis and review of these hypotheses are still at a very preliminary stage.

Empirical Data on African Famine Mortality Patterns

Studies of famines during the 1970s in Ethiopia and the Sahel drew attention to the dual but varied role of nutritional deprivation and increased disease exposure in elevating mortality. In Harerge (Ethiopia) in 1973-4 over half of the sixty five villages studied had over 20% mortality of under fives, with mortality highest amongst pastoralists (Holt *et al.*, 1975), and 'families interviewed claimed that the chief cause of death was starvation through shortage of milk and cereals' (Seaman *et al.* 1978:37-8). But in Wallo (Ethiopia) in 1972-3 Crude Death Rates reached 82/1000, compared to a 'normal' of 20-30/1000 (as observed in 1969 (Seaman and Holt, 1975).[11] Famine was triggered by soaring grain prices due to food hoarding, and led to severe economic disruption, especially for pastoralists, but destitution and hunger for only a small proportion of the population (Seaman and Holt, 1975; Rivers *et al.* 1976). Nearly three hundred thousand virtually destitute people gathered in relief camps, but received rations only sufficient for around 65,000 (Rivers *et al.* 1976:351); but despite the severe hunger: 'How many died of starvation and how many because of the poor hygiene of the camps in not clear' (Miller and Holt, 1975:169). (See also Seaman and Holt, 1980:294.)

From this experience the major relief agencies derived the important relief principle of avoiding creating concentrations of displaced people wherever possible, and establishing public health programmes to tackle the problems of those concentrations that still inevitably arise.[12] For example, Merkle (1976:358), who was a doctor involved in the relief effort in Ethiopia in the early 1970s observed:

> 'The main aim of our relief work was to go to the people with help and not wait for the arrival of migrated people in the shelters along the road, where the slum situation created more problems than the famine itself'.

Studies by researchers from the Centers for Disease Control (USA) reported excess levels of mortality in the Sahel famine in the early 1970s.[13]

Despite the high mortality reported in some of these spot surveys, the general concensus amongst demographers is now that the high mortality estimates for the famine were exaggerations; for example Caldwell emphasises that the mortality impact was rather low, and certainly lower than in the famine of 1913 (1977:93-5; 1984:4; and also Caldwell, 1981).[14] In retrospective studies asking the number of children ever born and the number surviving in Central Mali in 1981-2, there was no evidence for any kind of marked mortality change during or after the 1970s famine (Hill *et al.* 1982:48). The United Nations indicators for Sahelian countries have also shown little slowing of the existing trend to mortality decline, and the World Fertility Survey found no evidence for drought effect on mortality in those countries (Sudan, Kenya, and Somalia) for which data were available (Caldwell, 1984:14-5).

The lack of elevated mortality in the arable Sahel has been attributed to low levels of population displacement, in a situation where people could eke out the little food they had at home (Seaman and Holt, 1980:295; but see the contradictory evidence of Faulkingham below). But in the northern, mostly pastoral Sahel, where there were large numbers of famine-migrants at risk from measles and other disease. Here: 'The experience of the refugee camps when first established was of high levels of infectious disease, but this apparently arose largely from concentrating populations of nomadic children who had previously been more protected from epidemics by their scattered settlement pattern', but this did not lead to great mortality elevations as 'in any case the outbreaks were soon brought under control' (Caldwell, 1977:94). (See also Imperato, 1976:296 for measles control in Mali.) However, reports of elevated measles during the Sahel famine largely reflected only better surveillance, and a shift away from immunization in the years immediately prior to the drought (Caldwell, 1977:94).[15]

The only prospective study of the population dynamics of a semi-arid savannah population through high and low rainfall years was undertaken by Faulkingham in Niger over the period of the Sahel famine (Faulkingham and Thorbahn, 1975; Faulkingham, 1977). A Hausa village of 1500 residents was surveyed by a resident researcher through three visits before, during and after the Sahel famine. The village was unusual compared to its neighbours in that it was at a particular stage in the village development-cycle at which emigration to neighbouring villages and to Nigeria was less easy and prevalent, though there was increasing long-range dry season labour migration to West African coastal states (Faulkingham and Thorbahn, 1975:474-5). This may mean that patterns of mortality are atypical of the settled Sahel as a whole, as any 'health crisis' effects of famine distress migrants seen in other populations were by definition absent. Nevertheless the result is important as elevated mortality is observed after severe food shortage without distress migration.

Up until the drought virtually ended there was no elevated mortality, though the difficult conditions may have slowed the secular improvement in mortality (Faulkingham and Thorbahn, 1975:477). But the severity of the food situation at the last stages of the drought were correctly predicted as likely to lead to marked subsequent mortality after the departure of the researcher (Faulkingham and Thorbahn, 1975:477). Returning after the drought the researcher found that despite the fact that crop production in 1974 was as high as that in 1969 (Faulkingham, 1977:152), death rates had risen from the 18/1000 (mean 1969-73) to 43/1000 and 41/1000 in 1974 and 1975 respectively. This mortality partly reflected a spinal meningitis epidemic in October 1974 to March 1975 (1977:153), which may not be linked to the famine at all. Small African populations are certainly vulnerable to severe short term changes in mortality rates irrespective of rainfall-ecological factors.[16] However, there appears little doubt that marked time lags in the impact of severe food shortages are the likely cause for elevated mortality in 1974, and the death rates may have been even higher than reported (see below).[17]

During this period of elevated mortality with the end of the drought itself, Faulkingham's data suggest that it was mortality in the one to four year old age group that was elevated the most (1977:153). Yet examination of fertility data suggests that misreporting may be disguising infant mortality and/or female infanticide. Fertility was said to have collapsed, but examination of the data for 1974 reveals that there were 33 male children and just 17 female children reported born (1977:153), a non-credible sex ratio for births ($p<0.05$ by χ^2). The implication is that the baby girls were born, but died without having been reported, and may even have been killed. If there had indeed been equal numbers of male and female children born, infant mortality due to the drought would have been three times that reported by Faulkingham. Reasons for elevations in infant deaths will be returned to in the discussion below on the effect of maternal nutrition on birthweight and neonatal mortality.

Mortality was investigated during the 1984-5 famine in Darfur in the Western Sudan by de Waal (1989a and 1989b) who has argued the case for a health crisis cause of elevated famine mortality, rather than one driven by starvation. Relying on the method of recalled mortality in the interviewed household (see General Methods, footnote eighteen for a critique), and a 'normal' Crude Mortality Rate of as low as 13/1000, mortality is said to have trebled in 1985 (de Waal, 1989b:176). Recognising that his Infant Mortality Rate data were inadequate, and possibly under-reported to around 30% or more (1989a:8+13, and 1989b:176); de Waal focused on the causes of excess child mortality. Three factors pointed to child mortality being largely a function of increased disease exposure, rather than a result of declines in nutritional status; but in each case methodological problems weaken or question the conclusions. Firstly, certain sites had much higher mortality than others, and that this correlated to (descriptive) material on 'disease environment' (health services and water supply), rather than food situation (de Waal, 1989b:185).[18] Secondly, single round interview data on socio-economic status showed little correlation with household mortality levels (de Waal, 1989b:182-8).[19] It was further noted that 'starvation' was never recorded as a cause of death (de Waal, 1989b:186-8).[20]

It is important to note that Dar Fur people (at least male household heads) chose to suffer tremendous hunger for longer term economic and social benefits (de Waal, 1989); but de Waal (1989b:189-90) considers that the level of nutritional stress in Darfur was insufficient to lead to increased susceptibility to infection or death. Some anthropometric data are available from other sources for Darfur and Kordofan (Mohammed,1986, quoted in Rivers, 1988; and Shepherd, 1977:29) that suggest cross-sectional levels of 10-25% below 80% weight-for-height among children; and on the particular situation of the Chad border in September 1985, Red Cross surveys found that 93% of refugees and 53% of locals were moderately or severely malnourished (1989b:235). These levels are sufficient to be associated with significant increase in mortality risk (see below); and other 'maladies of famine', such as vitamin deficiencies may also have had considerable impact, as they did the same drought in north eastern Sudan (see Chapter Five, Section 5.3 and below). In addition, by focusing away from infants, he has also ignored the relationship between maternal nutrition, birth weight and vulnerability to death (see below).

Some further rather sketchy data draw attention to increased mortality resulting from a combination of food shortage and poor health conditions in camps of displaced people in Northern Uganda,[21] Biafra,[22] and Southern Mozambique.[23] Turkana populations in semi-arid Northern Kenya are also stated (without data presentation) to have higher mortality in drought years (Brainard, 1986), but is not known whether this reflects displacement as well as food supply and direct disease environment effects.

Several studies of refugee camps in the Horn of Africa and elsewhere indicate that elevated mortality can result from inadequate access to food in camps where refugees do not have other sources of livelihood.[24] This experience means that currently the greatest concern amongst relief professionals is to ensure adequate ration provision, without which even effective public health cannot prevent elevated mortality.

This discussion indicates that, in addition to severe food shortage, displacement is a critical stage in the process through which drought leads to mortality becoming greatly elevated in the semi-arid savannahs. Such extremes of hunger and economic distress have not occurred on a large scale leading to distress-migrancy in recent Zimbabwean history (but consider Ndanga in 1917: Iliffe, 1990:65-7; and the Protected Villages of the Liberation War: Weinrich, 1977:226-7). Indeed, throughout this period, famine mortality has been shown to have negligible demographic impact (Iliffe, 1990). Though there has been much population movement for trade and cattle grazing, and by people seeking to live in better endowed areas, these were basically 'first order' drought coping strategies, and led to little elevation in exposure to infection. It appears that the more subtle effects of maternal and child nutrition and direct disease environment effects are likely to be the major factors in contemporary Zimbabwe.

The Relationship Between Child Nutritional Status and Mortality

There has been a long gap between the early classical studies demonstrating higher mortality amongst hospitalised malnourished children (Gomez *et al.* 1956), and the recent prospective field studies of the same relationships. However, there now exist eleven data sets, (Bangladesh [six sets], India, Indonesia [two sets], New Guinea, and Zaire).[25] These exhibit a pattern where mild and moderate malnutrition leads to increases in mortality risk of between negligible and four fold, whilst severe malnutrition exhibits a threshold effect whereby mortality is raised to above ten-fold the mortality for the not malnourished population (see Martorell and Ho, 1984, for the discussion of the threshold concept). Despite the generally similar patterns demonstrated in the data to date, the precise relationships can indeed be expected to vary between areas (ie. disease environments) and populations (Chen *et al.* 1980a:1843; Kasongo Project Team, 1983:73; Pacey and Payne, 1985:40, 93; Alam *et al.* 1989:88). It may emerge, for example, that amongst certain pastoral peoples of the Sahel and the Horn - where populations tend to have generally lower anthropometric status (Chapter Five, Section 5.3), the threshold for mortality elevation may be lower.

All but three of the studies consider weight-for-height status amongst other anthropometric variables. Though one study examining this variable found no relationship with mortality until it was 'severe' - below 70% of international standards - (Chen *et al.* 1980a), four of the other studies found that mortality was elevated between two and four fold the 'well nourished' levels, when at a level of 'moderate' malnutrition, between 70 and 80% weight-for-height, (Heywood, 1983; Kielmann and McCord, 1978; Kasongo Project Team, 1983; Alam *et al.* 1989), one recorded it double between 60 and 80% (Handayani *et al.* 1983), and one found mortality double in the group <90% versus those over 90% (Sommer *et al* 1983).[26] Where populations have been examined below 60 or 70% weight-for-height mortality rates have been observed to be very greatly elevated (Chen *et al.* 1980a; Handeyani *et al.* 1983; Kielman and McCord, 1978). The most interesting data was that of Bairagi *et al.* 1985, which compared the relationships both during and after the 1974-5 famine in Bangladesh. During the famine even at 85% weight-for-height, mortality was four times that at 95%, and at 75% it was around ten times as high. Some months after the famine, mortality was still elevated at 85%, and was worse at 75%, but the effects were much less dramatic than for the same levels of nutritional status outside of the famine. Weight-for-height has been found a less valuable indicator of mortality risk than weight-for-age and arm circumference by Chen *et al.* (1980a), Bairagi *et al.* (1985), and Alam *et al.* (1989).

Using weight-for-age criteria elevated mortality is encountered in the populations studied to date only at very severe levels of malnutrition [<60% international standard], (Chen *et al.* 1980; Heywood, 1983; Bhuiya *et al.* 1989:359); though some increase below 80% was noted by Alam *et al.* 1989, before a 60% threshold to twenty-fold increases in mortality. Likewise height-for-age comes into effect below around 85% (Heywood, 1983; Chen *et al.* 1980; Bairagi *et al.* 1985; Alam *et al.* 1989), and height had mortality effects independently of weight-for-height (Heywood, 1983:139). Arm circumference has proved the most powerful predictor of mortality where it has been utilized (Sommer and Loewenstein, 1975; Chen *et al.* 1980a; Trowbridge and Sommer, 1981; Briend *et al.* 1987; Alam *et al.* 1989). Weight-velocity is only a powerful indicator of mortality risk over very short time intervals (Bairagi *et al.* 1985).

The reasons why the various anthropometric indices have different strengths of relationship with mortality risk are little understood; but may reflect underlying relationships with body fat levels (J. Seaman, pers. comm. 1990).

The consistent manner in which these relationships between nutritional status and mortality have been revealed suggests that increases in mortality are likely in most populations where there is moderate and especially severe malnutrition, and that these effects may be especially marked in the periods of socio-economic disruption termed famine. Such a relationship should be perceived as interactive with other socio-economic mortality determinants, rather than as a biologically determined fact. For example, Chen *et al.* (1980a:1842) found that incorporating maternal height, weight and dwelling size greatly increased the degree of relationship between anthropometric status and mortality. Likewise amongst children dying in Indonesia, there was a marked relationship between little maternal education and poor child nutritional status; whilst no relationship was found between low education and malnutrition amongst matched survivors (Handayani *et al.* 1983:91). However, attempts to control for nutritional versus socio-economic factors shows very clearly that nutritional status (<60% weight-for-age) has a much stronger influence in Bangladesh (Bhuiya *et al.* 1989:361-2).

This discussion of the relationship between anthropometric status and mortality risk can be directly related to whether the levels of nutritional decline occurring in clayveld during drought (Chapter Five, Section 5.3) were sufficiently marked to lead to increase mortality risk. Data for the drought of 1986-8 show that mean weight-for-age status declined from around 88% of NCHS to 83% at the lowest point (January, 1988); and the distribution of children in different weight-for-age categories is presented in Table 7.2.2.1.

Table 7.2.2.1 Distribution of Children by Weight-for-Age (0-10 Years Old) in Peak Drought Period (January 1988) on Clayveld

Weight-for-Age (% NCHS)	Numbers of Children	Percentage of Children
100.1 and over	5	10.0
90.1 - 100.0	8	16.0
80.1 - 90.0	21	42.0
70.1 - 80.0	12	24.0
60.1 - 70.0	4	8.0
Total	50	

Notes to Table 7.2.2.1
As demonstrated in the text of this section weight-for-age is the best predictor of mortality risk in most studies, apart from mid-upper arm circumference, which I did not collect in Zimbabwe.

Increases in mortality risk for children between 60% and 80% weight-for-age are generally reported as negligible in the studies quoted above; and furthermore, only a third of the children in Mazvihwa entered this anthropometric bracket. This suggests that good nutritional status prevented child mortality increase during this drought period. It is not possible to ascertain retrospectively what the levels of nutritional status decline were in the previous periods of dearth in this population, but the data from 1981-4 appear similar to that from 1986-8. A nutritional survey taken in the very same community in the drought of 1960 reported high levels of malnutrition (Iliffe, 1989), but the primary data has not been located. Insofar as the current agro-ecology of drought vulnerability and socio-economic situation can be backdated as representative in the clayveld population (to around the early 1960s in this area: see Appendix Two), direct nutritional stress in children has played only a small role (if any) in elevated mortality in droughts.

Nutritional Deficiency Diseases and Mortality

Field studies of drought and 'famine' affected populations in Africa have tended to place little emphasis on vitamin and other micro-nutrient deficiencies, as indeed I have in this study in Zimbabwe. In this section I document that these do occur, and that they can be expected to significantly contribute to mortality though probably mainly in situations more extreme than experienced in recent years in Southern Zimbabwe.

Concern for vitamin A deficiency in the famine-affected and displaced has become well-established (Rivers, 1988; *The Lancet* Editorial, 1989). Data on such vitamin deficiencies during drought and famine are presented in Chapter Five, Section 5.3. Recent research has now begun to produce quantitative data on the extent to which vitamin A deficiency increases vulnerability to infection and mortality.

The first major population-level study into the effect of mild vitamin A deficiency on mortality rates was made through eighteen months prospective monitoring of 3,500 Indonesian pre-school children (Sommer *et al.* 1983). Children with mild xerophthalmia and/or Bitot's spots experienced, on average, four times the level of mortality of the others, and this was independent of weight-for-height status, oedema, and levels of certain key diseases (respiratory, gastro-enteritis). Since around 5% of the children were vitamin-deficient, around 16% of mortality in this population of 1-6 year olds was directly associated with inadequate levels of vitamin A (Sommer *et al.* 1983). Research into the causes of this effect in this same sample found that children exhibiting mild xerophthalmia at both the start and end of observation showed twice the rate of respiratory disease and three times the rate of diarrhoea in the intervening period as matched controls (Sommer *et al.* 1984). In fact the impact on vulnerability to infection was probably even greater as it was masked in several ways by experimental design (Sommer *et al.* 1984:1094). Final 'proof' of the relationship was established by supplementation with vitamin A of half of a prospectively monitored population of 26,000 in northern Sumatra, in which the supplemented children showed 34% lower mortality than the controls (Sommer *et al.* 1986).[27]

Vitamin A deficiency presumably acts through increasing vulnerability to infection, both through promoting keratinisation of the respiratory, gastro-intestinal and genito-urinary tracts, and hence easing bacterial colonisation and infection, but also through depressing immuno-competence (Sommer *et al.* 1983:588); for discussion of a specific role in measles see Nieburg and

Dibley (1986:310). Recent research with measles has found that Case Fatality Rates are higher amongst hospitalized children in Zaire with low serum vitamin A levels, than amongst matched controls (Markowitz *et al.* 1989); and even more significantly, randomized vitamin A supplementation of measles patients in Tanzania led to a considerable fall in Case Fatality compared to controls (Barclay *et al.* 1987).

Scurvy, the vitamin C deficiency disease, has also erupted as a result of famine and displacement in the Sahel and Horn of Africa, as well as in certain other areas, where the populations have lost access to fresh foods (see Chapter Five, Section 5.3, for a review). Attempts to monitor the effects of scurvy on mortality rates acurately have not been made, although scurvy can certainly be a fatal disease. Good evidence does exist for it having increased maternal post-partum death rates in a Somali refugee camp (Seaman and Rivers, 1989). Deaths from scurvy were reported in early colonial famines in Zimbabwe (Iliffe, 1990:64).

Pellagra has also been found associated with maize dependence during drought or with displacement (Chapter Five, Section 5.3). Pellagra has a severe functional impact, and must lead to elevated mortality risk (though this was not actually observed in the small hospital study of Gomez *et al.* (1956:81). Beri-beri also occurred in Mauritania during the Sahel famine (CDC Final Report, in Sheets and Morris, 1976:142; Greene, 1974:1094), and may have also had an effect on mortality. Other likely micro-nutrient deficiencies (for example zinc) remain uninvestigated in African famine and refugee situations.

Maternal Nutritional Status, Birthweight and Infant Mortality

There has been little attention to Infant Mortality Rates during periods of famine/dearth, partly because the research methods used are often inadequate to obtain the required data (see above). Furthermore, it has been assumed that infants are protected from the rigours of famine through being breastfed. It has indeed recently been established that lactation is more resilient to maternal nutritional stress than had been previously believed (Prentice and Prentice, 1988), although the psycho-social and extreme physiological disruption of famine may well lead to higher levels of lactation failure than is commonly recognized. Additionally, research is establishing that maternal antibody content of colostrum milk is virtually independent of maternal nutritional status (Garg *et al.* 1989).

This section now examines a factor in Infant Mortality Rates that has been neglected in the recent African famine literature, the marked effect of reduced birthweight on mortality. It should be noted that there are many factors that strongly influence birthweight that are independent of current physiological stress or 'famine', including parity, maternal age and height. Although maternal height and body size is largely a long term consequence of nutritional conditions, it is weight that is relevant for famine or dearth.[28]

A considerable body of evidence show that maternal nutrition and health strongly affect birthweight (see review in Chapter Five, Section 5.1). This has been demonstrated as an effect of famine, as a feature of seasonal cycles, and as a result of socio-economic differentiation, and experimental diet supplementation has been shown to increase birthweight. This section now examines the large body of evidence that links birthweight to mortality; though it should be noted that gestational age interacts with birthweight in determining mortality risks for given birthweights (Lubchenco *et al.* 1972).

Since clayveld birthweight tends to decrease following drought, whilst sandveld birthweight is depressed during high rainfall (Chapter Five, Section 5.1), such dynamics could well be reflected in inter-annual changes in infant mortality. Recent droughts (particularly 1981-4) were capable of lowering birthweight sufficiently on clayveld to mean that a significant proportion of births were low birthweight, and thus exposed to higher mortality risk (see Chapter Five, Section 5.1). On sandveld, in contrast, it is <u>high</u> rainfall in the current year that leads to declines in birthweight, and again the effects quite marked (Chapter Five, Section 5.1).

Studies of the neonatal and infant mortality rates by birthweight for over a thousand births in eastern Kenya recorded highly significant relationships. Half of the children with birthweights of under 2kg died before the age of one year, and over ten percent of those with birthweights between 2kg and 2.5kg died. Above this weight infant mortality was only around 2.5%; both Neonatal and Infant Mortality Rates were effected by birthweight (Voorhoeve *et al.* 1984:234). Similar relationships and mortality levels were found in Mata's major study in Santa Maria Cauque [Guatemala] (1978:155-5). Hospital mortality in Ghana increased steadily in babies under 2.5Kg (Hollingsworth, 1965:297); likewise four years of birthweight and mortality-in-first-week monitoring in Dar es Salaam and Kampala found higher mortality in births under 2.5kg, with a particularly extreme relationship with births under 1.4kg (Ebrahim, 1969:102-3). National survey data for Zambia recorded that the highest foetal death rate levels were in the regions with lowest maternal haemoglobin and serum protein levels (Kwofie *et al.* 1983). Low birthweight was also shown linked to increased mortality in a Sri Lanka hospital study (Soysa and Jayasuriya, 1975:10). A major research project in Guatemala has shown that a wide variety of anthropometric measures of the new born, as well as birthweight, show close correlations with mortality (De Vaquera *et al.* 1983; Landicho *et al.* 1985); and birthweight was one of the important factors responsible for differences in infant mortality between socio-economic groups (Lechtig *et al.* 1978b). Increasingly large western data sets have been used to model declining mortality up to 4kg, followed by an increase with extra-large babies (Wilcox and Russell, 1983:319-20).

Supplementary feeding of pregnant women in Britain during World War Two, actually decreased perinatal mortality compared to pre-war years (Bergner and Susser, 1970:958). Research at the time showed that micro-nutrient supplementation (vitamins A, D, B complex, and minerals Ca, P and Fe), reduced both stillbirths and neonatal mortality by around 20-30% in several British populations (People's League of Health, 1942); supplementation had similar effects in Toronto (Ebbs, *et al.* 1941). More recently, experimental diet supplementation of African mothers under nutritional stress, increased birthweight and child growth, and, more importantly, reduced stillbirth, neonatal and perinatal mortality rates by half (Herrera *et al.* 1980). Similar results have been obtained in other studies (Lechtig *et al.* 1982).

In an important post-war paper on the Siege of Leningrad, food shortages were shown to lower birthweight by over 500g on average, resulting in lower infant vitality, higher morbidity and higher mortality (Antonov, 1947). The still birth rate was also increased (Antonov, 1947). The data from the Dutch Hunger Winter have produced less clear results. Birthweight was reduced, by about 300g on average (Smith, 1954:235), but the number of really low birthweight babies (<2.25kg) actually increased only marginally (1954:238). Although Smith (1954) stressed that stillbirth and neonatal mortality were not raised by the famine, subsequent analysis has suggested that there were some complex relationships, with perinatal mortality elevated for those conceived during the famine (and often born afterwards), rather than neonatal mortality being raised for those actually born during the famine (Stein *et al.* 1975:184-7; Wynn and Wynn, 1982). (Only babies born during the famine actually had depressed birthweight [1954:236], as nutritional status effects birthweight only in the last trimester.) A general conclusion that can thus be drawn from studies of the impact of famine on the outcome of pregnancy is that nutritional stress in early pregnancy directly affects survival and development, whilst stress in late pregnancy has an impact largely via birthweight (Bergner and Susser, 1970:958). In a situation like the Dutch Hunger Winter where there was not actually an increase in low birthweight babies, even though average birthweight fell, the only impact apparent was that babies conceived and spending early pregnancy during the famine had higher subsequent mortality, but this was often expressed only later when the actual 'famine' had passed.

Despite this evidence for a nutritional link with perinatal and infant mortality, and the work on famine in Europe, there is very little data for recent 'Third World' famines. As indicated by the review above, there has been no attempt to collect reliable infant mortality rates during African famines. But in the Bangladesh famine of 1974-5 Chen and Chowdhury compared prospectively collected mortality data for the famine with that from 1966-71 (see Watkins and Menken, 1985:655). This study found that neonatal mortality rate remained unchanged, whilst post-neonatal infant mortality rate doubled (Chen *et al.* 1980b:29). This meant that overall infant mortality rose more (35%) than 1-4 year child mortality (27%).[29]

Studies of perinatal mortality as a function of birthweight have found significant and surprisingly constant relationships in the white and black populations in New York and Britain (Bergner and Susser, 1970); and even between Latin Americans and other 'Third World' populations and births in the West (Mata, 1978:164-5). However, whilst the extent to which 'maternal-environment' controlled birthweight determines levels of perinatal mortality is very substantial, there are also some differences in death rates for given birthweights between social classes, and racial groups, and some historical changes (Bergner and Susser, 1970). This observation of fairly predictable mortality relationships is of immense value to the field epidemiologist/anthropologist, as it means that even without collecting enormous amounts of prospective birthweight and mortality data, it is possible to associate limited evidence for changing birthweight with that for changing neonatal or infant mortality, and draw a credible conclusion.

Inter-Annual Rainfall Variation and Infant Mortality Rates in Mazvihwa

Methodology and the problems involved
Infant Mortality Rates (IMR) are calculated as the proportion of live births said by mothers to have died before the age of one year. There was some bunching of children reported to have died at 'one year', and these were included with the deaths under one in the calculation of IMR.

Mototi sandveld and boundary populations are combined to increase sample size, on the basis of their continuing to show generally similar patterns.

Data is analysed post-1950 only, as the sample sizes are too small and data probably too inaccurate before this date. With the investigation of changing mortality rates in runs of years, the analysis starts in 1952 as this is the beginning of a wet run of years. In the mortality rates calculated for different amounts of rainfall, the twenty five years of data end with the 1973-4 season, as after this the effects of the war and demographic transition associated with Independence become apparent, and would have to be controlled for. With the dry and wet runs, 1981 is a more convenient cut-off point for a run of wet years.

Although calculating IMR is relatively straightforward, it is more difficult to relate calendar year IMR to rainfall year data, in which the bulk of the rain falls in December to February (see Chapter Three). The way that I have done this is as follows. Births in year x are considered in the same year as rainfall in the meteorological year July (x-1) to June x. This is because the bulk of the rainfall in that rainfall year will fall in year x, and the harvest from the crops be received and eaten through year x. However, approximately half of the children born in calendar year x will not reach the age of one until the year x+1, and therefore can also be affected by the rainfall in the subsequent year. This is an impossible problem to overcome methodologically, so a further analysis has been conducted for mortality in the 'year' after.

Child (one to five years old) mortality also shows similar relationships with rainfall as does IMR. However, death rates are much lower in this category, and there are problems in calculating exposure rates in such a way as to make statistical tests still reliable. This data has therefore not been included in this analysis.

Infant Mortality Rates in wet and dry runs of years

Data in Table 7.2.2.2 present Infant Mortality Rates calculated for wet and dry runs of years. Statistical analysis supports the hypothesis that during drought clayveld (but not sandveld) mortality increases, whilst in wet runs of years sandveld IMR can sometimes be higher than clayveld. However, the method appears too crude to determine the relationship between birthweight and infant mortality.

Table 7.2.2.2 Infant Mortality Rates in Wet and Dry Runs of Years

	Mototi bound + sand			Mutambe sandveld			Mototi clayveld		
	n born	n die <1 yr	IMR/ 1000	n born	n die <1 yr	IMR/ 1000	n born	n die <1 yr	IMR/ 1000
Wet runs									
1952-9	26	6.5	250	-	-	-	44	3	68
1974-81	80	3	38	145	14	97	99	9	91
Dry run									
1960-73	64	5	78	185	20	108	140	17.5	125

Notes to Table 7.2.2.2
The IMR for Mutambe in 1952-9 has been discarded as it is believed that this one-off survey greatly underestimated early infant mortality in this sample (see Section 7.1). Although the Mototi clayveld IMR for this period is also low, it is believed representative because the IMR calculated for the 1930s and 1940s for this sample showed high rates comparable with Mototi sandveld and boundary; which suggests that there was no systematic under-recording of deaths in the early period.

The 'half' deaths recorded in two of the years are the deaths of children for whom there was no age data. It is assumed that they had a 50% probability to have died under one year, though in practice 70% of deaths under five were under one in the years in question. If they are more completely allocated to the infant category they further enhance the observed relationship between rainfall and mortality.

Notes to Table 7.2.2.2: Continued.
Using the binomial test of proportions the following results were statistically significant:
1. During the 1960-73 dry period clayveld IMR was higher than Mototi sandveld plus boundary ($z= 2.0$, $p<0.05$)
2. During the 1952-9 wet period Mototi sandveld + boundary IMR is indeed higher than clayveld IMR ($z= 4.4$, $p<0.001$). However during the 1974-81 wet period the opposite result is obtained ($z= 2.79$, $p<0.01$)
3. Clayveld IMR is indeed higher in dry periods than wet periods ($z= 2.28$, $p<0.05$), whilst sandveld results are about equal

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Impact of droughts and wet years on Infant Mortality Rates

The direct impact of single years of high, medium or low rainfall on infant mortality is now examined. Rainfall levels were hypothesised to be capable of effecting birthweight both in the current year (Table 7.2.2.3) and in the year following (Table 7.2.2.4). The former would largely reflect disease environment, whilst the later would mainly be a product of the nutritional effect of the amount of grain harvested in the previous season.

Table 7.2.2.3 Infant Mortality Rates in Years of Low and High Rainfall

	Mototi Bound + Sand			Mutambe Sandveld			Mototi Clayveld		
Rainfall	n born	n die <1 yr	IMR/1000	n born	n die <1 yr	IMR/1000	n born	n die <1 yr	IMR/1000
Drought (<450mm)	36	3	83	93	7	75	71	10	141
Average (450-650mm)	40	5	125	51	7	137	70	5	71
Wet (>650mm)	36	3	83	69	8	116	65	6	92

Notes to Table 7.2.2.3
Using the binomial test of proportions the following results were statistically significant:
1. In clayveld drought years show higher IMR than non-drought years ($z= 2.81$, $p<0.01$)
2. In the two sandveld populations drought years show lower IMR than non-drought years ($z=2.37$, $p<0.05$)

Table 7.2.2.4 Infant Mortality Rates in Years Following Years of Low and High Rainfall

	Mototi Bound + Sand			Mutambe Sandveld			Mototi Clayveld		
Rainfall	n born	n die <1 yr	IMR/1000	n born	n die <1 yr	IMR/1000	n born	n die <1 yr	IMR/1000
Drought (<450mm)	42	3	71	93	12	129	72	10	139
Average (451-650mm)	37	4	109	57	8	140	79	4	51
Wet (>650mm)	33	4	121	63	2	32	55	7	127

Notes to Table 7.2.2.4
Using the binomial test of proportions clayveld births in the years after drought years had higher IMR ($z= 2.7$ $p<0.01$)

During years of high, medium and low rainfall, the Infant Mortality Rate changes in different ways in the sandveld/boundary and clayveld populations (Table 7.2.2.3). Current-year IMR is raised by droughts in clayveld, but actually reduced by drought in sandveld/boundary. Presumably this largely reflects the opposite disease environment effects of high rainfall in these zones (Chapter Six). The effects of very wet years on infant mortality in sandveld and boundary populations are somewhat confusing. Wet years appear to reduce IMR in these populations, though they would be expected to elevate it further on sandveld, due to disease-environment effects (Chapter Six).

Examining infant mortality after years of drought, medium or high rainfall, the ecological zones show the opposite pattern of relationships as expected (Table 7.2.2.4). Where there is drought in the previous year, infant mortality is elevated in clayveld, presumably because harvests are much more markedly reduced by drought in clayveld than sandveld (Chapters Three and Four), and that this has carry over effects on consumption and maternal nutritional status (cf. the data for children in Chapter Five, Section 5.3). If sandveld populations are considered combined, no relationship is observed with previous years' rainfall, but closer examination of the data indicates that this is because of opposite relationships between rainfall and mortality in the two samples. In Mutambe, high rainfall in the previous year leads to lower infant mortality; indeed a regression of 15 years of IMR (1959-60 to 1973-4) with rainfall had an R^2 of 0.14 with a F-test significance at p= 0.16. In contrast, in the sandveld and boundary population in Mototi, the higher the previous years' rainfall the higher the Infant Mortality Rate; a regression of twenty five years data (1949-50 to 1973-4) had an R^2 of 0.15, with a probability of 0.06 attached to F.[30]

Since both drought years, and the years following drought show elevated infant mortality in clayveld the two years were combined to illustrate how great was the overall impact of drought on IMR. IMR for drought associated years was then 138/1000, and in other years just 39/1000. The difference is highly statistically significant (χ^2= 5.14, p<0.05).

7.2.3 Conclusions to Section 7.2

Section 7.2.1 examines causes of death between the zones which appear to be broadly similar in the two populations, though there are minor differences in the importance of 'fevers' and 'measles', which may possibly reflect settlement pattern in respect to river water, and to household size.

Mortality levels as a reflection of inter-annual variations in rainfall, and during famine, are first reviewed. The data available, though very limited, suggest that in the moist savannahs drought actually reduces mortality by improving disease environment, without making a marked impact upon food supply. In the arid savannahs were drought often leads to famine both disease environment and nutritional factors are responsible for elevated mortality - where this does actually occur - though the extent that each contributes remains uncertain, and clearly varies. Demographic studies of the African famines have concentrated upon child mortality, but this is largely because the methods used have been crude and virtually unable to pick up data on infant mortality. There are good reasons to believe that the proportion of low birthweight babies rises during famines due to maternal nutritional stress, and that this is a major factor promoting higher infant mortality. This is despite the fact that breast feeding effectively protects the infants nutrient supply (lactation is very resilient to maternal nutritional stress: Prentice and Prentice, 1988), and also confers greater immunological defence against infection (Garg *et al.* 1989).

Infant Mortality Rates for Mazvihwa are quite sensitive to levels of rainfall. Disease environment contrasts mean that current year infant mortality increases in drought years in clayveld, but decreases in such years on sandveld. The effects of rainfall on previous years harvests also appears to be significant. In clayveld, where harvests are highly rainfall-dependent, drought in the previous year reduces infant survival, but this is not the case in sandveld/boundary populations. Taken together, therefore, drought-associated years have more than treble the infant mortality in the clayveld population, but lower IMR in the sandveld/boundary sample. Presumably most of the effect acts through maternal physiology and birth weight, though there may also be direct effects upon the infant. It is therefore a function of ecological dynamics how different African savannah mortality rates will vary with rainfall.[31]

In the next chapter marked differentials in the mortality levels are revealed with wealth, maternal education and religion. However, since it is not possible to assign current wealth measures to households in past years it is not possible to reliably investigate wealth differentials in drought mortality. In Chapter Nine historical changes in mortality are discussed, in particular recent reductions in infant mortality since Independence (1980).

7.3 Birth Order, Birth Interval and Mortality

This section examines the effects of birth order and birth interval on infant and child mortality.

Table 7.3.1: Effects of birth order on infant mortality rate
All zones pooled, 1950-87

Birth order	n born	n died	IMR
1	194	13	67
2	174	20	115
3	161	14	87
4	141	11	78
5	110	8	73
6	99	4	40
7	80	12	150
8	56	6	107
9	41	1	24
10	23	1	43
11	12	2	167
12	6	1	167
over 12	8	1	125

Notes to Table 7.3.1:
Apart from birth orders nine and ten, birth-orders above and including the seventh carry higher mortality risk, but this is not statistically significant.

7.3.2 Under Five Death Rates by Preceding Birth Interval

Preceding Birth Interv	One Year	Two Years	Three Years	Four Years	Five Years and over
Total births	48	374	123	41	36
Deaths 0-5 yrs	7	69	13	3	1
Deaths/1000	146	184	106	73	28

Notes to 7.3.2:
Table 7.3.2 is based on all births recorded since 1950 up to 1979 from both the Mototi and Mutambe samples.

Intervals of 'one', 'two', etc. years are not true intervals. This data was obtained from calculating the difference in the years of birth. For example, a child born in 1967 with a previous child born in 1964 has a three year birth interval according to this method. This introduces serious bias with the one-year birth interval as births are distributed around twelve months in a highly skewed fashion as none are less than nine months and some as long as one year eleven months. However this will not bias the relative mortality rates within the sample, though caution should be exercized if comparing them to other populations.

Note that according to research by Castle and Saphire (1976;967) the mean birth interval was 1.97 years in a rural area north of Harare (Umvukwe).

The distribution of deaths across all categories is uneven; $\chi^2 = 11.57$, 4df, $p<0.05$

Birth order has no clear systematic relationship with infant mortality in this sample population. Preceding birth interval appears to have a considerable effect on mortality. One year birth interval has a slightly lower mortality-risk than two year interval, and from two years increasingly lengthy birth intervals have steadily lower mortality-risk.

The effects of birth order on anthropometric status and mortality appear to be rather different in each population examined (eg. Longhurst, 1984, appendices). This is presumably because the impact of this variable is reflects both the domestic cycle as well as underlying maternal physiological competence. Differences in the domestic organization of production and consumption between societies will cause variations in timing of the patterning of physiological stress on mothers and their babies. Minimal effects of birth order were seen in my Zimbabwe data (Table 7.3.1) in contrast, for example, to elevations seen in first birth and above ninth birth in Senegal (Rosetta and Quigley, 1988:74; Rosetta, 1988d:61) and small declines in mortality with birth order observed in the Gambia (Billewicz and McGregor, 1981:232-3).

Elevated first birth mortality is so generally observed that the lack of this in my data must raise a question whether some mothers did not reveal such deaths during the interviews. (On the other hand, the preferential treatment generally given to women in southern Zimbabwe at their first birth, when they usually return to their natal home, may be sufficient to lessen mortality, A. Cornwall, pers. comm., 1988; though it is not as substantial as that provided to the primiparous women among the Ntombe, Pagezy, 1983). There is a little elevation for the seventh birth and above (on average), which is also a typical feature of birth order data (Bongaarts, 1987), but this was far from statistically significant. Too much attention has been given to the effect of this variable, given the fact that it cannot be meaningfully manipulated as a component of a policy to reduce mortality. Furthermore, the nature of the variable makes identification of the intermediate causal factors very complex. This birth order effect is returned to in Chapter Nine in consideration of how contraceptive extension is affecting current mortality trends in Zimbabwe.

It is commonly observed that short preceding birth intervals tend to expose the subsequent child to elevated stress and enhanced mortality (Bongaarts, 1987). An impressive early study of seven million births between 1937 and 1941 in the USA, utilizing still birth rates for women with different parities at the same age, demonstrated a clear relationship between short intervals and higher subsequent still births (Yerushalmy, 1945). A careful study in Equador (Wolfers and Scrimshaw, 1975) found that shorter birth intervals, whatever the outcome of the previous pregnancy, resulted in higher rates of still birth and infant mortality, even in within-family (ie. highly controlled) analysis (1975:489-91). Similar results have been obtained in some African studies (Laurie *et al.* 1954; Cantrelle and Leridan, 1971; Rosetta, 1984; and a study in Nepal: Carlaw and Vaidya, 1983); but this was not found in a study in Western Nigeria (Doyle *et al.* 1978), a result which the authors explained as reflecting adequate levels of child care and food access. UNICEF (1988:35) have produced an Africa-wide estimate whereby Infant Mortality Rate for births with intervals less than two years is 133/1000, and for over two years just 78/1000.

Data presented in Table 7.3.2 are notable in that there is an improvement in survival with progressively longer birth intervals above two years, and with both infant and child mortality. This suggests that direct inter-sibling competition could be important, because in an interval longer than two years marked physiological impact of the previous pregnancy and lactation is no longer present. The concept of inter-sibling competition needs to be distinguished from that competition for maternal physiological resources that occurs when there are two pregnancies very close together, and results in deaths early in life. In the latter case children are competing for the allocation of time and other resources (money, food, etc.) from the mother long after any effects from pregnancy have disappeared. A similar effect is reported in a study of Singapore children by Martin (quoted in Doyle *et al.*, 1978), in which anthropometric status and school achievement at the age of nine years was found to reflect previous birth interval.

It should be noted that stillbirth and infant mortality are also characteristically <u>followed</u> by shorter than average birth intervals (cf. Wolfers and Scrimshaw, 1975:492-4; Billewicz and McGregor, 1981:235). However, this was not investigated in this Zimbabwe sample, as it was not relevant to the current research themes. The implications for understanding sibling competition from these birth interval effects on mortality rates is taken up in Chapter Eight in discussion of the impact of under five (not only under one) mortality on the anthropometric status of surviving children.

7.4 Sex Differentials in Welfare

This section examines evidence for sex differences in welfare variables for children under ten years of age. As the quantitative data suggest minimal differences, this is then reviewed in the light of other African and international literature.

7.4.1 Sex Differentials in Infant and Child Mortality Mototi and Mutambe samples combined

	# births	# deaths <1 year	IMR	# deaths 1-5 years	CMR	Mortality 0-5yr/1000
Males	565	50	88	18	32	120
Females	573	44	77	20	35	112

Notes to Table 7.4.1:
Data is for all live births recorded in both Mototi and Mutambe samples earliest birth; 1932

Differences are not statistically significant

IMR: Infant Mortality Rate (<1 year)
CMR: Child Mortality Rate (1-5 Years)
All rates per 1000

7.4.2 Sex differentials in Infant and Child Mortality (clayveld sub-sample)

	# births	# deaths <1 year	IMR	# deaths 1-5 years	CMR	Mortality 0-5 yr
Males	190	20	105	8	42	147
Females	188	17	90	10	53	143

Notes to Table 7.4.2:
Data is for all live births recorded from women in this clayveld sub-sample, earliest birth 1935
Differences are not statistically significant

7.4.3 Sex differential in anthropometric status of two to ten year olds clayveld sub-sample

Sex	Ht/Age n	Ht/Age mean	Ht/Age σn-1	Wt/Age n	Wt/Age mean	Wt/Age σn-1	Wt/Height n	Wt/Height mean	Wt/Height σn-1
Males	15	94.7	4.51	17	86.9	10.97	36	96.9	6.90
Females	38	94.9	3.38	37	87.5	9.95	54	96.3	6.39

Notes to Table 7.4.3:
All data are % of NCHS standards, reference date September 1986 or nearest month within two months

A sex bias whereby more females were measured than males, is not due to biases in the frequency of measuring but is the result of an anomolous sex birth sex ratio in the 1980s: 79 males born to 97 females. In earlier periods this birth ratio was largely reversed. The reasons for this are unknown, but it does not reflect infanticide or reporting errors.

7.4.4 Sex differentials in morbidity in under ten year olds Clayveld sub-sample only

Sex	n child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
Males	335	143	42.7	48	14.3	50	14.9	20	6.0
Females	435	172	39.5	49	11.2	65	14.9	19	4.4

Notes to Table 7.4.4:
Larger sample size for females is consequent on the sex ratio; for explanation see Table 7.4.3.

For detail on the morbidity assessments see Chapter Six. ENT refers to ear, nose and throat infections. None of the differences approaches statistical significance.

Differences in reported morbidity probably do not hide sex differentials in attitude to children of different gender, as treatment appears identical (see Table 7.4.5). In some areas, including in Moslem Africa (El Samani *et al*, 1988:103) parents give earlier and higher reporting of diarrhoea for boys compared to girls.

7.4.5 Sex differentials in response to morbidity in under ten year olds; Clayveld sub-sample

	n morb	no treat. n	no treat. %	home remedy n	home remedy %	purch med n	purch med %	oral re-hyd n	oral re-hyd %[1]	VHW n	VHW %	clinic n	clinic %	hosp. n	hosp. %	church n	church %
Males	143	52	36	22	15	19	13	5	10	9	6	33	23	0	0	9	6
Females	172	70	41	25	15	26	15	7	14	12	7	27	16	6	4	14	8

Notes to Table 7.4.5;
1. The percentage of treatments by oral re-hydration solution is as the percentage of diarrhoea cases experienced.

No Treat.: There was no treatment for the complaint, as it was considered minor, or there was nothing that the parents felt they could do.
Purch med: elementary western medicines, such as headache pills, bought from local stores
VHW: Village Health Worker providing western medicines for elementary diagnoses

Note that the number of children reported treated by n'anga ('traditional healers') was too small (three cases) to make data presentation worthwhile.

None of the differences in the table are statistically significant, when clinic attendence and hospital attendance are combined.

Discussion

Data for mortality (7.4.1 and 7.4.2), anthropometric status (7.4.3), morbidity (7.4.4) and response to morbidity (7.4.5) all suggest that there is little or no sex differential in welfare provisioning of under ten year olds in the Mazvihwa sample. This lack of sex differential is the justification for pooling the sexes in each of the analyses reported in this thesis.

Inequality in welfare provision between the sexes is well established in Bangladesh and North West Indian areas (e.g. Levinson, 1974; Dyson and Moore, 1983), though it is uncertain the degree to which this is a function of food discrimination or health care use (Basu, 1989). Sex bias has also been demonstrated in Jordan (Tekce and Shorter, 1984) and Guatamala (Delgado *et al.* 1983:231); and its degree can be related to differences in gender roles in relation to returns on parental investment.

Welfare data differentiated by sex are infrequently reported in Africa south of the Sahara. The general consensus seems to be that differences are insignificant. Twenty Sub-Saharan Africa anthropometric data sets recently analysed by Svedburg (1988) all showed little sex difference or a slight bias against males, except in some data for Nigeria. Additional studies not reported in Svedburg support this conclusion. Rosetta (1988d) reports no sex difference in anthropometric status for children in Senegal, and girls show the expected slightly lower mortality in this population (Rosetta and Quigley, 1988:75). Wilson (1985:68-9) reports better anthropometric status for girls than boys in the six to ten year age group in Ugandan refugees in the Yei, South Sudan in 1984; and De Waal (1987:125-6) recorded lower mortality in girls than boys in the five to nine year age category in the 1984-5 famine in Darfur, Western Sudan. Both differences were attributed by local people to older girls preferential access to food during cooking.[32] In a study of food intake in Senegal, Rosetta (1988e:285), draws attention to the impossibility of accurately assessing women's nutrient intake during the food preparation stage, which tends to counter the showy preferential male access to food during mealtimes.[33]

However, some sex differences in African populations have also been reported by other workers. Caplan (1988), found male bias in Muslim Mafia island (coastal East Africa) in anthropometric status, clinic attendance and mortality. Tripp (1981:19) found slightly better anthropometric status in boys (non-significant), who tended to eat with their fathers, but their was no bias in treatment of morbidity.

Studies in Zimbabwe also suggest equality in treatment between the sexes, with slight biases in welfare status against boys.[34] The 1982 Zimbabwe census recorded slightly greater mortality in male infants, and so confirms that there is not sex-bias in mortality in this population (C.S.O. 1985:167). (Since males are biologically more vulnerable than females: Rivers, 1986). Daly *et al.* (1973) report sexes separate data for an undated survey for Epworth Mission and Chizungu Primary School near Harare, Zimbabwe. Both 7-11 year old boys and girls followed the 10th percentile (standards undefined, probably Boston) for weight-for-age and height-for-age (1973:234-5). A survey of 224 children at Catholic missions in Mondoro, Chikwakwa and Chinamora (Communal Areas of highveld sandveld) in November 1965 found that at eighty months both boys and girls were around 10% lower than British standards for weight, and were of similar height. At 150 months the boys had deteriorated to 15% lower than British standards of weight, whilst the girls were just 6% lower. The girls averaged 4cms taller than the boys (93.7% NCHS compared to the boys 92% NCHS). Data I collected in three primary schools in Mazvihwa collected in July and October 1986, and January 1987, and involving children aged from seven to around sixteen years, showed no systematic difference between the sexes, using NCHS sexes-separate weight-for-height standards.

People in the Zimbabwe study area denied (if asked) that they provide preferential treatment to boys or girls and there was no overall sex preference for births (Cornwall 1990:64). The data evaluated in this study do indeed support their statements.[35] Equality of general treatment does not mean that there are never cases where children receive preferential treatment because of their sex. For example, within a family of predominantly the opposite sex a single girl or boy does tend to receive more lavish attention.

There has been a historical trend towards declining male bias in this society due to the weakening of the father-son patrilineal linkage, and the corresponding rising contribution of daughters to parental welfare (F. Shumba, pers. comm., 1988). Rises in bridewealth payments are certainly important to reinforcing this trend. Of greater significance is that wives now have greater ability to direct resources from their new homes back to their parents, and this, in turn, reduces the amount of support sons can give their parents. Greater parental acceptance of female-education and rises in pocket money allocations to girls have reflected this process. However, it remains speculation whether stronger male bias in the past was reflected in biological welfare variables, other than in mortality in which it was not.

7.5 Concluding Discussion to Chapter Seven

This Chapter has traced out the basic relationships between the socio-ecology of the production systems, and fertility and mortality. The contrasting ecological dynamics between sandveld and clayveld, which have been shown to lead to differences in seasonal and inter-annual variations in nutrition and health (Chapters Five and Six) were therefore hypothesised to have similar effects on fertility and mortality.

Data on fertility suggest that though ecological dynamics strongly influence marriage rates, through the effects upon ability to meet bridewealth payments, the effects on seasonal and inter-annual birth rates are negligible. Seasonality in births is similar in all zones, and appears dominated by patterns of labour migration, with peak conception occurring during times of holiday leave (Christmas and Easter). Such effects of labour migrancy are common, but not universal in Africa: more research is needed in areas where there do seem to be ecological factors at play. Birth rate is apparently unaffected by rainfall. Apart from some poor quality data suggesting that fertility declines in famines, this is an unresearched area in Africa, beyond unproven notions that year by year variations maternal nutrition status will be directly reflected in birth rates.

Whilst there are no data on seasonality in mortality, comparative data do hint that there may be different regimes in the semi-arid and moist savannah regions of Africa, that might also occur in the study area. Analysis of inter-annual variations in infant mortality were very fruitful. Existing material in the literature suggests that drought might lead to reductions in mortality in the moist savannah areas, just as it leads to improvement in nutrition status and morbidity. This effect is probably largely due to improved disease environment. In contrast in the semi-arid savannahs drought appears to elevate mortality. The reasons for this include a worse disease environment during drought, nutritional stress, and public health effects of displacement and concentration of destitute populations in camps. In my own analysis I concentrate on the effect of declining maternal nutritional status and elevated morbidity on birth weight, drawing on material from Chapter Five, Section 5.1; and hence increasing infant mortality. This is an approach not previously pursued in African drought/famine literature, let alone for explaining increased mortality in wet years in moist savannahs. The results of analysis of data for Mazvihwa over recent decades are very interesting, as the effects appear substantial. Drought on clayveld trebles infant mortality in that year and the one following. In contrast these years are marked by lower infant mortality in the sandveld/boundary zone. This is a further illustration of the value of deriving hypotheses about mortality dynamics, and interpreting the results, from an ecological viewpoint.

It is worth noting that differential migration between the ecological zones in response to rainfall-led ecological productivity have been shown to occur in Chapter Four. During a period of extended drought there was much greater out-migration to urban and high-rainfall areas from the clayveld than the sandveld-boundary; the latter zone even receiving immigrants from the clayveld (Chapter Four, Section 4.1).

The Chapter closes with consideration of two other demographic issues. The first, Section 7.3 an examination of birth order, birth interval and mortality briefly traces some basic relationships that are important background to analyses of the nature and causes of differentiation (Chapter Eight) and change (Chapter Nine) in demographic variables. Finally, in Section 7.4, sex differentials in nutritional status, morbidity and mortality are investigated, and found to be non-existent. This is important to establish since analyses in the other chapters rely on pooling populations by sex.

Sections 7.1 and 7.2 in this Chapter conclude consideration of my initial hypothesis that contrasting ecological dynamics between zones would lead to opposite patterns of seasonal and inter-annual welfare stress with rainfall. This hypothesis having been largely confirmed I now turn my attention to the socio-economic and historical context in which these relationships exist; further analysis frames the limits within which the (apparently) ecologically-determinist relationships are constructed. In Chapter Eight I explore how the relationships between social and economic processes at the mother-child interface, and the household and lineage levels shape child welfare. I also explore whether the marked differentials unveiled are reflected in seasonal and inter-annual dynamics. Then in Chapter Nine I turn to the considerable historical changes in welfare variables, most obviously in fertility and mortality since Independence (1980). The explanation for such changes, I posit, must necessarily involve how the national political economy has affected domestic relationships beyond (yet in the context of) ecological dynamics.

CHAPTER EIGHT
SOCIO-ECONOMIC WELFARE DIFFERENTIALS AND THEIR ECOLOGICAL INTER-RELATIONSHIPS

Introduction

Whilst material on assets, production and consumption showed considerable socio-economic differentials between households (Chapter Four), the analysis made to date on seasonal and inter-annual dynamics in nutrition (Chapter Five), morbidity (Chapter Six) and fertility and mortality (Chapter Seven) has examined the changing welfare status of all the children (or women) in a given zone without reference to these differentials. Furthermore, up to this stage in the thesis I have examined child welfare status in this area without reference to the "health revolution" which has occurred in Zimbabwe since Independence (1980), which has apparently halved Infant Mortality Rate an issue addressed in Chapter Nine. In this chapter I now switch attention to these issues of welfare differentials; examination of these data demonstrate both the considerable degree to which socio-economic factors can affect child welfare, but also the limited extent to which these can protect children from the impact of ecological dynamics within this rural society.

A review of existing African research, in the context of wider literature, establishes the basic framework for hypotheses and analysis. The results are then presented, and they are finally discussed and interpreted in light of the literature and the analysis in earlier thesis chapters.

Part One: Welfare Impacts of Social and Economic Differentiation: Literature Review

Introduction

Although there is a growing amount of attention being given to social and economic differentiation in African rural societies, very little detailed research has been conducted into the welfare impacts of this differentiation. Authorities who argue that there is insufficient differentiation in rural Africa to create welfare differences (eg. McLean, 1984), are likely to be on the retreat. On the other hand social scientists have to come to realise that inequality as perceived by researchers in rural Africa, will not be simply and directly reflected in child health variables.[1] Welfare differentials therefore need to be investigated both in terms of the social context and meaning of differentials (and their child provisioning effects), and through rigorous measurement of child welfare variables. This is how I proceed in this thesis.

A variety of factors limit the effect of household socio-economic differentiation on child welfare in most rural African situations, in contrast to the societies of south Asia and elsewhere (cf. McLean, 1984). The first of these is that indicators of 'wealth' in Africa do not relate sufficiently closely to actual 'consumption' by the children in the households concerned. This is due to the limited degree to which most African households represent discrete egalitarian food/income consuming units. Much production/income is directed towards, or derived from, outside of the household as part of the handling of various kinds of lineage relations and other inter-household relationships. Such arrangements may include redistribution as insurance so as to secure assistance in times of stress. The effect of this is that cross-sectional studies will find that children do not benefit from current wealth (as it is being 'insured' in other households), or suffer from short term poverty (as they are, in turn, receiving assistance from other households). An alternative, though actually related factor, is that many senior male household heads use their wealth to secure political patronage rather than to improve their children's welfare.[2] Households considered 'wealthy' because of holding many assets and status goods (such as tin roofs, radios, bicycles, livestock) are often those where male households heads are able to divert consumption and expenditure from women and children towards making and maintaining such status investments. Finally, membership of a household does not necessarily mean an equal access to resources; for example in wealthy households there are often large numbers of non-directly family children (and sometimes adults), living in the home but receiving less favourable treatment. Furthermore, even within the biological family, especially in polygynous households, there is frequently discrimination.

A second factor is that examination of the impact of socio-economic differentials often ignores the <u>origin</u> of those differentials, and how "getting wealthy" can negatively affect welfare. Whilst many workers apparently assume that it is privileged access to the means of production in terms of assets such as land or cattle that is responsible, in many African situations wealth differences actually have their origin in control of labour. Therefore in such circumstances households are actually wealthy because women and children are being obliged to work harder, a fact which may cancel out any welfare benefits to them of higher production. Even without this wealth being a result of harder work, children under ten in richer households have been shown in Bangladesh to have to work harder to maintain households, assets, and enterprise (Cain, 1977), and this is probably also the case in Africa.

Third, whilst economic differentiation can make households live at different levels on average, frequently it is what happens at certain critical stages (eg. of acute sickness) that determines welfare outcomes. In many African societies, the rich provide support to the poor at such times, both as they find themselves physically obliged given local socio-political organisation, and also because that support is used to enhance their prestige and/or political control. Mitigation of nutritional stress in rural West Africa by such relationships is discussed by Fulton and Toulmin (1982) Watts (1983) and Tripp (1981).

Fourth, a basic limitation on the capacity of socio-economic differentiation to lead to welfare differentials is how difficult it is to purchase an improved disease environment in rural Africa; and disease is probably more important than nutrition in creating physiological stress and mortality in most rural African situations. Temperature, dust, humidity, water supplies, insect vectors, and air-borne infections are the main causes of ill-health, and each is quite difficult to counter-act.[3] (Note, that despite this there is indeed evidence that some mothers manage to reduce child morbidity and mortality substantially in identical disease environments.) This situation has a parallel in medieval Britain - and probably Europe - where wealth did not enable lower mortality up until the mid-eighteenth century (Livi-Bacci, 1983:295-6).

Finally there is an additional complicating factor in that household socio-economic status will probably have diverse impacts on welfare, some of which are positive, and others negative. Wealthier households, for example, tend to be larger, which might affect disease transmission (Last, 1970), and greater intensity of exposure to infection (Aaby *et al.* 1984). The economic activities of households of different socio-economic status also tend to be distinct. In many parts of rural Africa agriculturally wealthy families tend to accumulate livestock, which impose different health risks in themselves (eg. for *Campylobacter* in milk see below, and for tetanus see Ware 1984:198; Smucker *et al.*1980). Herding stock can also impose further health hazards for example to sleeping sickness in the bush, or schistosomiasis in swamp grazing areas or stock watering sites. Children in wealthier families may also travel more, leading to exposure differentials.

Other non-economic factors have been identified as differentiating variables affecting welfare in rural Africa: maternal 'attitudes', education and religion. Not much work has been conducted on maternal attitudes and knowledge but this is presumably important. Maternal education has been shown to have marked effects in Africa and elsewhere, distinct from any relationship it has with purely economic factors, though the reasons for its impact are still uncertain (Ware, 1984). Religion can have an impact especially when it effects treatment of disease (notably through prohibitions over western treatment by fundamentalist African Christian groups). There is no evidence, however, that subjectively inferred differences in hygiene or life-world attitude between religions are reflected in child welfare, except perhaps for Islam, which is not a factor in rural southern Africa.

Empirical Data on the Impact of Socio-Economic Differentiation

Birthweight and perinatal/infant mortality

Studies that have compared birthweight of different socio-economic groups in Africa have all found significant relationships, which presumably reflect the strong effects that nutritional deprivation and maternal morbidity have on birthweight (see Chapter Five, Section 5.1). Hospital birthweights of privileged women were found to be greater than those of the general populace in each study undertaken in Africa and Asia.[4] However, none of the studies in Africa have examined socio-economic birthweight differentials within a single rural population; for which my study is therefore the first attempt.[5] Since there are such close correlations between low birthweight and neonatal and infant mortality (see Chapter Seven, Section 7.2) it can safely be assumed that birthweight differentials were reflected in mortality. Indeed there is excellent data for the mortality impact of low birthweight being significant amongst poor population sectors in the Guatemala studies.

Economic Differentiation and Infant and Child Welfare

In the longitudinal study of child welfare in The Gambia, little impact of socio-economic differention on welfare was found. McGregor *et al.* (1970:70-1) have argued that whilst the economic differences between households were quite considerable, they could not be used to achieve better environmental health.[6] The ownership of livestock, for example, meant higher milk intake, but this was often contaminated and may have led to higher morbidity. Generally speaking poor nutritional status and high mortality were a function of disease rather than food availability *per se* (1970:69,74-5).[7] Thus the better diets of the richer provided little direct welfare benefit. Differentiation was in any case blunted by mutual aid in time of crisis (1970:71). Richer households also made the same enormous demands on women's labour (1970:71).

A useful contrast can be drawn with a study in a nearby urban area of the Gambia (Bakau), where socio-economic differentials were indeed demonstrated in height-for-age and weight-for-age (good long term indicators: Bairagi, 1987), though not in weight-for-height (Tomkins *et al.* 1986b). Presumably in an urban setting, the economic differences were both more marked, and more 'expressible' than in the rural Gambia area discussed above.[8] A study in northern Ghana also throws useful light on these rural-urban contrasts (Tripp, 1981). Within the agricultural sample there were no nutritional differentials (in weight-for-age); even those hiring farm workers had children who were no larger than those of other farmers (1981:19). On the other hand where the father, or especially mother, was a <u>trader</u> the children were of substantially higher nutritional status (1981:19-20).[9]

In the Dutch/Kenyan Machakos study of a highly differentiated East African society there was marked inequality in access to land and urban employment. Supposedly related factors, grouped as agricultural potential, wealth, modern orientation, and hygiene all showed a number of significant correlations with different causes of death (Gemert *et al.* 1984), though why the particular associations were found was not generally apparent or explored further.[10] Analysis of each factor independently produced fewer statistically significant relationships between socio-economic variables and infant mortality rates in this study (Voorhoeve *et al.* 1984:266). For example, with 'agricultural potential' none of the production variables (crops, livestock, etc.) was significant when examined independently. The two important variables were household agricultural implements (called 'professional possessions') and the presence of planted fruit trees! Membership of the 'cash-crop' co-operative was also significant. Family structure and education were not significant, and the only hygiene variable significant was the number of children sleeping in a room. Important variables that I would term 'wealth' were also significant (Voorhoeve, 1984:266-7): quality of house, number of rooms, and presence of means of transport (bikes, motorbikes and even cars). The interviewer's own personal observation of hygiene and conditions was also statistically significant.

Voorhoeve *et al.* conclude that what is most striking is that despite such clear economic differentiation in this population, the 'poor' still only have somewhat worse infant mortality than the better off. They related this to the fact that the population is by no means 'destitute', and that:

> 'Under these circumstances it seems that parental care and foresight is more important for the children's well-being than actual income or possessions. In these times of recession, scarcity and unemployment, the father who builds a decent house and the mother who plants some fruit trees around it are a sign of hope for the next generation' (1984:269).[11]

There is some evidence from another area of East Africa that the relationship between land access and child nutritional status is growing as land becomes shorter, and thus differentiation in resource-access more marked (Emster *et al.* 1976). Jakobsen (1987) in the Southern Highlands of Tanzania compared children of the poorest subsistence households with middle income and high income rural producers. Although there were some compounding effects of altitude and isolation (1987:238), the data show that the poorest children had the best nutritional status, the middle income the worst, and the richer children intermediate status (1987:234, 241-2). He invokes changes brought by monetization and associated processes of intra-household authority which eroded the situation of women and children, who only begin to reap welfare benefits once the household is really wealthy.[12] As he stresses (1987:235) it is best not to conclude from this that:

> it is better to be economically unprivileged but rather that economic privileges in this society tend to be men's privileges, and they tend to manifest themselves in ways which are not beneficial to the children's diet'

Cash cropping in these differentiated agrarian communities has been found to have varied and often contested impacts upon child welfare.[13] This is partly because of the conflict faced by women between agricultural production and child care; for example intensive maize cash-cropping in northern Zambia appears correlated with lower nutritional status because of resulting inadequacies of time for child care (Moore and Vaughan, 1987).[14].

In northern Tanzania, regional variations in production and wealth showed a greater relationship to child mortality and life expectancy than did health service provision (Sembajwe, 1983). However, socio-economic indices co-vary closely with altitude and thus with less threatening disease environment; the 1973 national census data found altitude the single strongest predictor of life expectancy in Tanzania. Appreciating regional variations in disease environment can contribute to understanding regional mortality differentials in Sudan, Kenya and Tanzania (Farah and Preston, 1982:373-4), and probably also in Zimbabwe (see Section 8.2); and in Swaziland where anthropometric status declines with attitude due to an as yet unknown combination of disease environments (malaria and schistosmiasis) and nutritional determinants (Huss-Ashmore and Curry, 1989:204-5).

Longhurst (1981) postulates an 'energy-trap' whereby the rural poor in Northern Nigeria cannot achieve sufficient return on expended energy to meet their nutritional requirements. However, the children of the poor in his sample were not actually thinner or smaller than those of the richer echelons of rural society, who were in positive energy-balance at the level of the household economy. Similar nutrition status is alleged to be due to higher morbidity in the children of larger, generally richer families (cf. Last, 1970). Indeed, despite seasonal economic stress being most severe for poorer farmers, Longhurst and Payne have observed that: 'No quantitative evidence on the differential impact of seasons on nutritional intake by income class has been found' (1981:49)

The strongest relationships between socio-economic variables and nutritional status would be expected in the poorest populations such as refugees (Wilson, 1985).[15]

Data on Economic Differention and Welfare for Zimbabwe

Rural differentiation is quite marked in Zimbabwe (Adams, 1987, 1988; Jackson and Collier 1988), and this has important social, economic and political implications (eg. for livestock policy and land use planning: see Scoones and Wilson, 1988). It is often assumed or stated that this inequality has effects upon welfare, but there is little data for contemporary Zimbabwe to substantiate this (Loewenson and Sanders, 1988:148). The studies that have been made are now reviewed.

A hospital study in the city of Harare of forty sequential malnourished admittances with matched controls in May-July 1982 identified several factors more frequent in the malnourished group (Waterston and Nhembe, 1984). These were: mothers on less than $50/month (ie. poverty), rural origin, large family size, substitute mothering and living a long distance away from a clinic. The complex social origins of these children, which may, by the very nature of their affliction, be different from the controls, make interpretation of the results difficult. Variables such as distance from clinic, rural origin, large family size and low income are presumably correlated anyway. Given the partial urban orientation of the study, the results have limited bearing on rural situations.

Dahlin and Dahlin (1983) reported on 200 consecutive admissions during 1982 at Mnene (Mberengwa), a hospital less than 50km from the study area. This was in a drought year, but in a sandveld area, where drought does not reduce anthropometric status (cf. Chapter Five); however Mnene does also receive patients from clayveld. There was no correlation between malnutrition and the number of children per family, the marital status of the mother, and only a very slight effect of cattle ownership (owners 12% severe malnutrition and non-owners 19%). Cattle ownership is a very good proxy for 'wealth' as defined by the communities in this region (Chapter Four). Thus the study of Dahlin and Dahlin suggests that household wealth shows little correlation with malnutrition during drought in this region of Zimbabwe.

Theisen (1976b:94-5), in his little known and very thorough Chiwundura (Zimbabwe) study in the early 1970s, did find relationships between measures of 'stress' (which he designed as a more appropriate proxy for wealth, that incorporates security) and height-for-age anthropometric status in children. Those at 'subsistence' level had 40% below the 10th centile on Harvard, whilst the below subsistence categories -1 and -2 had 50% and 71% of children below this cut-off respectively. Above subsistence categories 1 and 2 were 26% and 25% below that standard respectively. Theisen believed that levels of protein intake were responsible, as height-for-age correlated with the incidence of protein foods in the diet (1978b:196). Therefore, contrary to the study of Dahlin and Dahlin (1983), but using a rather more sensitive measure, Theisen found evidence of very marked nutritional differentials in relation to wealth. It should be noted, though, that Chiwundura is a very different society to that of Mberengwa, and this might explain the greater degree of nutritional differentiation. Chiwundura has higher population density and despite higher rainfall there is greater resource pressure. Furthermore, it is largely composed of immigrant peoples with much greater urban linkages and individualised production (Drinkwater, 1989; D. Jeater, pers. comm., 1988). A final report deserves mention - that of observation in four of the five provinces that areas with the most precarious food supply (and measured by 'food supply until harvest time') had the greatest proportion of children with low Mid-Upper Arm Circumference (Sanders, 1982a:204).[16]

Maternal Education, Religion and Attitudes

Studies of maternal aptitudes and attitudes, and their relationships to child welfare are generally still at a very preliminary stage. Attempts to correlate attributes with nutrition have been instructive, but are clearly flawed if they are considered to be causal or mechanistic. Directly measuring attitudes proved a powerful tool in one piece of research in Mexico (Cravioto, 1979), but another study has shown the relationship between knowledge/behaviour and nutrition is highly complex (de Chavez *et al.* 1974). In a study of semi-destitute traumatized Ugandan refugees in the Sudan, a very strong association was found between severe depression (and other neuroses) and malnutrition (Wilson, 1985:79). This may have reflected a combination of:

(1) an association between social vulnerability, poverty and neuroses;
(2) depression developing in part as a result of child malnutrition and sickness; and
(3) parental neuroses increasing likelihood of child malnutrition.
(Wilson, 1985:79-81).[17]

Maternal education has been shown to be correlated with significant differences in infant and child mortality in Latin America, Asia, and Africa (Ware, 1984:191). Two major and very carefully controlled statistical studies of this have been made in Africa (Caldwell, 1979 from a Nigerian survey conducted in 1973; and Farah and Preston, 1982, using the 1973 census data from the Sudan); each shows that the effect is of enormous significance. A recent analysis of data from Ghana (Tawiah, 1989) also found that the census variable with strongest association with survival to the ages of two and five was maternal education, followed by paternal education, husband's occupation and mother's occupation; type and place of residence were least significant.[18] Despite the clear importance of maternal education, and as Ware's insightful essay clearly shows, little progress has been made with identifying the causes of these relationships, once they can be divorced from effects of other subtle socio-economic variables that are likely to be closer to the proximate 'cause' of death.

Caldwell (1979), Ware (1984), and Chen (1986) have postulated a range of ways in which maternal education might affect infant and child mortality in the absence of effects on overall household 'wealth'. It could be that relatively educated women are more assertive and better able to command resources within the household. Education might also increase confidence and efficiency in the use of available household resources, and reduce fatalism in regard to child morbidity. Education might in itself provide knowledge enabling women to manipulate the outside world better, eg. to get attention in clinics. It is doubtful, however, that educated women know more about child nutrition and care, since these topics are generally not usefully taught in formal education; even minimal primary schooling has effects on mortality; and, thirdly, belief and knowledge are entirely different anyway (Ware, 1984:194).[19] However, more educated women may make earlier and/or more effective use of health care services. Several studies have also suggested that independent of economic factors the children of educated women experience lower morbidity (Freij and Wall 1979; Agarwal *et al.*, 1982; Black, 1984:181; Bertrand and Walmus, 1983; Hoskins, 1988); but this is not always the case (El Samani *et al.*, 1988:104). A final factor is the later marriage and lower fertility of more educated women.

The degree to which womens' education can enable them to effect changes in infant mortality must surely be a function of the environment in which they live, and the kinds of privileges in access they can command. Pollani (1981). Flegg (1982) argues that the effect of education will be most marked in otherwise egalitarian societies. Ware (1984:197) adds that differentials will become smaller the greater the degree of popular extension of health services (citing Cuba). Farah and Preston (1982:373-4) show that mortality differentials with education are much greater in the southern region of the Sudan where there are poorer health services, in line with Ware's reasoning. However, Orubuloye and Caldwell (1975:268-9) found bigger mortality differentials with maternal education where there were health facilities.

The Orubuloye and Caldwell (1975) study in Western State (Nigeria), in an area which had a good medical service, the women with more education purchased more medicines privately but used the free government health services less (1975:264-5) than the rest. Due to the importance of malaria in this area, and of the high effectiveness of the malarial medicines that were frequently purchased, the authors concluded that purchasing of medicines might have contributed to reduced mortality (1975:271-2), even though most of the medicines purchased were essentially useless or even dangerous. The causes of the reduced use of the health service by the educated in the area with a good service remains uncertain; but in a village which was far away from effective medical services Orubuloye and Caldwell

(1975:265-6) did find that more educated women made higher use of medical facilities for their children.

In a study in rural South Africa (Transkei), Westcott and Stott (1977:966-7) showed that whilst maternal education alone showed no relationship to child anthropometric status, tests on knowledge of baby care and the causes of malnutrition, (according, no doubt, to the stereotypes of medical clinics), found good associations with child malnutrition. Good growth was as a function of persistent baby clinic attendance and also correlated with improved diet under health education; casual baby clinic attendance had no effect on nutritional status.

Studies in Tanzania, Malawi, Java and Bangladesh suggest that the impact of material education on nutritional status is most marked in situations of stress.[19a] Theisen (1976b) reported that the effect of maternal education on child welfare in an area of Zimbabwe, was considerable on both child anthropometric status and mortality.[20] Theisen argued that it was naive to believe that education and other factors could operate independently of eachother in a causal fashion (1976b:94-5), and therefore he designed an integrated "stress" scale. Theisen states that education improved agricultural innovation in women (1976:95), though it is not clear in what ways, which is important given that Theisen has elsewhere shown that most agricultural recommendations in the area were basically misguided (eg. 1978a). Only with secondary schooling did Theisen believe there was any change towards westernized attitudes (eg. to family planning) (1976b:95). It should be noted that maternal education is not always correlated with child anthropometric status, for example it was not in a study in South Africa (cf. Westcott and Stett 1977:966), and level of maternal education education was not found associated with diarrhoeal morbidity in Southern Nigeria (Huttly *et al.*, 1987:866-7).

A study in south eastern Nigeria comparing the nutritional status and mortality of 'innovators' and 'traditionalists' found substantial differences, which could be related to acceptance of western health care, vaccination, and public health education (Scheer and Ebrahim, 1985), without differences in wealth. However, the criteria used for delineating the sub-samples are not presented, though the authors notes that the innovators tend to be Christian.[21]

In Zimbabwe religious affiliation was reflected in differentials in child growth and mortality in Chiwundura (Theisen 1978b:169); Seventh Day Adventists and Salvation Army members tended to do better for their children due to their being socially 'more cohesive', farming more productively, and consuming less beer (1976b:97); a similar result was found in a survey in South Africa (F. D'Souza, pers. comm., 1989). Apostolics may have been shown in a recent Zimbabwe study to experience higher mortality (B. Kinsey pers. comm. 1988). Apostolic sects in other parts of Southern Africa are widely believed to experience higher mortality but published data are lacking.[22] In analagous fundamentalist Christian sects believing only in curing through prayer and religious ritual in Western State, Nigeria, Orubuloye and Caldwell (1975:264-5) found that they do indeed make markedly less use of modern health facilities, though effects of this difference are not investigated. In another study in this part of Nigeria, Morley *et al.* (1968) report that there was no difference in anthropometric status by parental religion.

Conclusions

This literature review has demonstrated that wide ranging associations between socio-economic factors and infant and child welfare have been found in studies in Africa and elsewhere. At the same time, it is clear that there has been inadequate research into identifying all the possible inter-relationships and causal factors. Notable emergent issues, pertinent to the analysis and conclusions to be drawn in this chapter, are the complexity of relationships between economic variables and welfare (whereby wealth is associated with both better and worse child welfare in different contexts), and the salience of maternal education as an important variable (despite the fact that the causes of the effects cannot easily be located). Religious variation within a 'community' may also have an impact, particularly when it dramatically effects the use of medical services, or leads to marked differences in social organisation.

Data Analysis

Introduction

Data for differentiation in the welfare variables for this population are now presented. Section 8.1 examines birthweight, Section 8.2 nutritional status, Section 8.3 differentials in morbidity and in treatment, and Section 8.4 considers mortality. Finally, in Section 8.5, the welfare variables in households experiencing elevated infant mortality are examined as an alternative route to identifying linkages between socio-economic status and welfare differentials.

First, however, cross-tabulations of these variables are presented below to show that the observed welfare differentials are not simply a consequence of strong (and possibly dependent) associations between the socio-economic variables.

Table 8.0.1 Cross-tabulations of differentiation variables

Religion	Maternal Education 6+	3-5	1-2	illit	unknown	Household Wealth 1	2	3	4
Miss	1	9	5	6	6	12	3	9	4
Trad	4	6	3	8	5	7	5	6	7
Zion	4	3	1	2	1	3	3	2	3
Apost	1	2	4	3	4	5	4	3	2
Unknown	5	5	3	5	6	11	2	7	3

Mat Educ	Household Wealth 1	2	3	4
6+ years	6	3	2	3
3-5 years	6	7	8	4
1-2 years	9	2	5	3
illit.	10	3	6	6
Unknown	9	2	8	3

HHold Org	Household Wealth 1	2	3	4
Male-Head	8	5	12	11
Male-Absent	5	6	6	2
Female-Head	2	0	2	1

Notes to Table 8.0.1;

Wealth categories

Wealth categories 1 to 4 were assigned to each 'household' by three discussion groups, under the co-ordination of Ian Scoones. More detail is presented in the General Methods Chapter. The first was a sub-sample of men from the sample, the second a sub-sample of women, and the third the local research team members from the area. Very similar allocations were made by each group. A variety of factors were deemed critical to evaluating 'wealth' status by the locals involved, but most important was household-access to livestock for agricultural production, and other such productive assets. Long term access to remittance income that was being invested in rural infra-structure and welfare was also considered significant. Category 1 is the wealthiest.

Religious Categories

Zionism and Apostolism are Independent African Christian Churches. Members are generally subject to strong discipline, including a rejection of both 'western' medicine and indigenous *n'anga* herbalists.

Mission Christianity refers to membership of so-called 'mainline' Christian Churches (which are now effectively African-led). The three most important found in this area are Lutherans, Church of Christ and Catholicism.

Notes to Table 8.0.1 continued
The category 'traditional' was used for those who said that they appease ancestral spirits. For many adherents this is the most passive religious involvement. Referring to it as traditional does not mean that it is necessarily identical to that of the time of conquest.

Only one woman said that she had no faith, and the children in her care were excluded.
Some mobility in religious allegiance that may explain the weaker effects of religion in 1950-79 data

Members of churches, though generally enthusiastic, do not necessarily follow strict codes of practice in line with the national or international policies. For example, many members of churches that do not allow their members to use western medical treatment have a system of using the service and then 'repenting'; another example was a Catholic who told us her reason for being a member was that it encouraged family planning.

Educational Categories
The categories given are based simply on the number of years of Primary education, although the 6+ years category includes a few women who have completed secondary education. Thos women who were literate through adult education were allocated to the 1-2 years category.

Household Organisation
The terms 'male-headed' and 'female-headed' are used because they are the accepted terms in the literature. They do not relate to cultural categories in southern Shona areas, where households have <u>owners</u> who are physically responsible for a piece of turf on which others can chose to live subject to their authority, irrespective of their social relationships. (In one household in the sample there is a man living under the authority of his son, and this is not uncommon in the area.) Owners are responsible for establishing a secret medicinal charm (mbambo) to hold the home together. Although it is not theoretically impossible for women to be homestead owners within these rural areas, none was encountered who actually was; one reason for this is that these charms appear to contain fragments of charms passed down patrilineages. Women who run households in their own right generally do so in the name of their deceased husband. Women whose husbands are labour migrants are absolutely not seen as female household heads by locals, even if they are totally responsible for all management. In practice, they have extensive rights over day to day management but are subject to (often erratic) interventions by their husbands, mothers-in-law, and their husbands male patrilineal relatives. The husband sometimes moves one or two of the latter into the home to represent his interests and to help the woman with 'male' work tasks. It should be stressed that those households with the male household head absent should not be considered as the only households utilising remittance income. This is because remittances are often provided by other household members, particularly sons, but also daughters and others, and, furthermore, absent men remit highly variable amounts of money.

The household-head times wealth data is for only the boundary and clayveld samples, as the sandveld sample was biased toward wealthy households with the elderly men present.

Unknown data for maternal education and religion are mainly where a woman was ommitted from the interviews in error.

Attention to economic differentiation in the variables nutrition, health and mortality (the subjects of the three previous data chapters), should be based upon the analysis of wealth, production and consumption differentials in the rather contrasting clayveld and boundary populations (see Chapter Four). The analysis presented there both drew attention to how differentiated the population is, but also showed how this had rather ameliorated influences upon actual consumption of food, and perhaps, by implication, other welfare-influencing factors. The analysis of production/consumption relations, ties in closely with the introductory discussion in this chapter in terms of the importance at going beyond the household as a unit of analysis, both to look beyond it and so at lineage and other inter-houshold relations, and also to examine intra-household processes. A further important conclusion in

Chapter Four, was the observation that though differentiation had a significant impact upon how people experienced underlying ecological dynamics, it did not have sufficient impact to entirely overcome the ecological processes upon which production and disease environment are based (Chapter Three). This has bearing on the current analysis of seasonal and inter-annual variations in welfare stress in different economic categories.

8.1 Birthweight Differentials

Birthweight has been shown to vary seasonally and inter-annually in contrasting ways in the different ecological zones (Chapter Five, Section 5.1), and this may account for part of the contrasting inter-annual dynamics in infant mortality (Chapter Seven, Section 7.2). This section now examines whether there are socio-economic differentials in birthweights.

Table 8.1.1: Economic Differentiation and Birth Weight

Wealth	n	birth weight (kg)	σ_{n-1}
1	5	2.90	0.392
2	7	3.14	0.455
3	10	3.17	0.236
4	8	3.00	0.630

Notes to Table 8.1.1:
Birth weights were recorded by nurses at clinics and hospitals. It is not known the degree to which babies born in such units are a biased sample, but attendance is a common practise.

Table 8.1.2: Economic Differentiation and Birth Weight Sandveld/Boundary versus Clayveld

		Sandveld and Boundary			Clayveld	
Wealth	n	bweight (kg)	σ_{n-1}	n	bweight (kg)	σ_{n-1}
Categs 1+2	6	2.80	0.43	6	3.29	0.27
Categs 3+4	7	3.33	0.33	11	2.94	0.46
T-Test		2.29, 11df., $p<0.025$			1.9, 15df., $p<0.1$	

Notes to Table 8.1.2
Wealth categories one and two, and three and four, have been combined to better handle the tiny sample sizes. In the clayveld sample there are no birthweights in wealth class one. A comparison of birthweights of wealth category four (mean 2.73kg) with wealth category two is statistically significant ($t= 2.48$, 7df, $p<0.025$), even through categories 3+4 versus 2 is non-significant.

Although there appears to be no effect of economic differentiation on birthweight (Table 8.1.1), this is actually because there are marked and opposite effects in the clayveld and sandveld/boundary populations (Table

8.1.2). Birthweight is much lower in the wealthy households in sandveld and boundary, but much higher among better off households in clayveld.

Birth weight has been found related to maternal nutritional status in each investigation undertaken in Africa and elsewhere (see Chapter Five, Section 5.1). Unfortunately, only some weights for clayveld women in this sample are available, but these confirm the hypothesis that women in wealthy households in that particular zone are larger and hence produce bigger babies (Table 8.1.3).

Table 8.1.3: Economic Differentiation and Maternal Weight in Clayveld

Wealth category	**Weight (Kg)** n	**mean**	**σ_{n-1}**
One	6	68.0	8.1
Other	15	59.2	7.8
	t= 2.19, 19df, p<0.05		

Notes to Table 8.1.3
Women were weighed in August 1989 (ie, outside of the main research period) by Florence Shumba, with Abraham Mawere and Cephas Mawere, in connection with studies of the energetics of cereal preparation. They were not intended to be a systematic sub-sample from the clayveld population studied in this thesis. Also note that they include women beyond child bearing age.

Tables 8.1.4 and 8.1.5 now examine whether the different wealth categories demonstrate common patterns of seasonal and inter-annual variations in birthweight. Taken as a whole the sandveld/boundary population shows lower birthweight during the rainy season and in wet years, whilst the clayveld population has lower birthweight in the dry season and following drought years (see Chapter Five, Section 5.1).

Table 8.1.4: Effect of Economic Differentiation on Birthweight Seasonality: Contrasts between Sandveld/Boundary and Clayveld

	Sandveld/Boundary						**Clayveld**					
	Wealth 1+2			**Wealth 3+4**			**Wealth 1+2**			**Wealth 3+4**		
	n	**mean**	**σ_{n-1}**	**n**	**mean**	**σ_{n-1}**	**n**	**mean**	**σ_{n-1}**	**n**	**mean**	**σ_{n-1}**
Rains	3	2.46	0.17	1	3.20	-	3	3.37	0.35	3	3.25	0.26
Other	3	3.13	0.32	6	3.35	0.36	3	3.22	0.28	7	2.73	0.41

Notes to Table 8.1.4
Wealth categories have been combined as in Table 8.1.2. One birthweight could not be used in this analysis as birth month was uncertain.

Rains refers to December, January and February, as in the discussion of seasonality (Chapter Five, Section 5.1). 'Other' refers to all other birth months.

Table 8.1.5: Effect of Inter-Annual Variation in Rainfall on Birthweight: Contrasts between Sandveld/Boundary and Clayveld

Rainfall in Current Year

	Sandveld/Boundary						Clayveld					
	Wealth 1+2			Wealth 3+4			Wealth 1+2			Wealth 3+4		
	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}
Dry Yr	3	3.02	0.45	6	3.36	0.35	4	3.38	0.27	5	2.93	0.15
Wet Yr	3	2.57	0.35	1	3.14	-	2	3.10	0.13	5	2.84	0.64

Rainfall in Previous Year

	Sandveld/Boundary						Clayveld					
	Wealth 1+2			Wealth 3+4			Wealth 1+2			Wealth 3+4		
	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}
Low	6	2.80	0.43	3	3.20	0.07	0	-	-	7	2.83	0.52
High	0	-	-	4	3.43	0.44	6	3.29	0.27	3	3.02	0.13

Notes to Table 8.1.5
The following rainfall years were classified wet; 1979-80, 1980-1 and 1984-5. The following were classified dry; 1981-2, 1982-3, 1983-4, 1985-6 and 1986-7. Births were allocated to rainfall years in the same manner as explained in Chapter Five, Section 5.1.

Birthweight seasonality is similar in both wealthy and poor households (Table 8.1.4), and the data in Table 8.1.5 suggest that inter-annual variations in rainfall probably have similar effects in both wealthy and poor households in these populations.

Table 8.1.6: Maternal Education and Birth Weight

Education	n births since 1980	n weighed	% births weighed since 1980	birthweight (kg)	σ_{n-1}
6+ years	26	6	23	3.15	0.36
3-5 years	50	11	22	2.98	0.37
1-2 years	23	5	22	3.17	0.72
illit.	33	4	12	3.09	0.46

Notes to Table 8.1.6:
Educational categories are based on the number of years of primary schooling. The 6+ years includes some women with secondary education. The 1-2 years category includes a few women literate without formal schooling.

Birthweights of illiterate women are under-represented, suggesting that they are less likely to give birth in clinics or to retain the record and provide it to researchers.

Table 8.1.6 suggests that level of maternal education has no sharp effect upon birthweight, at least in clinic and hospital births, which are a lower proportion of births for illiterate women.

8.2 Nutritional Differentials

This section explores differentials in anthropometric status in relation to socio-economic factors. It looks first at underlying differentials using weight-for-age cross-sectionally. Then I examine whether there are seasonal and inter-annual variations in child growth between households with different economic status.

Household Economic Differentiation

First the effect of overall household economic status is assessed (Table 8.2.1), using weight-for-age, a variable shown to well-reflect long term nutritional factors (Bairagi, 1987). Similar results were obtained with height-for-age, but weight-for-height showed a smaller differential.

8.2.1: Effect of Economic Differentiation on Weight-for-Age

Part 1: Sandveld Sub-Sample

	Dry Season Early Drought (Sept 1986)			Wet Season Mid Drought (Jan 1987)			Dry Season After Drought (Jul 88)		
Wealth	n	Wt/Age	σn^{-1}	n	Wt/Age	σn^{-1}	n	Wt/Age	σn^{-1}
1	12	81.83	8.09	13	81.91	8.50	14	81.82	9.79
2	3	95.77	9.00	7	89.47	11.69	5	88.94	11.74
T-Test	2.43, 11df, p<0.025			1.57, 18df, p<0.1			1.25, 17df p<0.25		

Part 2: Boundary Sub-Sample

	Dry Season Early Drought (Sept 1986)			Wet Season Mid Drought (Jan 1987)			Dry Season After Drought (Jul 88)		
Wealth	n	Wt/Age	σn^{-1}	n	Wt/Age	σn^{-1}	n	Wt/Age	σn^{-1}
1	15	87.9	15.2	14	85.27	12.61	13	79.69	6.88
2	2	88.4	7.7	2	86.80	0.28	3	90.87	11.07
3	14	90.6	12.8	13	86.53	9.62	12	88.28	10.70
4	13	88.7	12.53	13	88.33	10.76	12	89.20	11.70
T-Test	1 v (2, 3 + 4) 0.41, 42 df p<0.4			1 v. (2, 3 + 4) 0.71, 40df p<0.25			1 v. (2, 3 + 4) 2.77 38df p<0.005		

Part 3: Clayveld Sub-Sample

	Dry Season Early Drought (Sept 1986)			Wet Season Mid Drought (Jan 1987)			Dry Season After Drought (Jul 88)		
Wealth	n	Wt/Age	σn^{-1}	n	Wt/Age	σn^{-1}	n	Wt/Age	σn^{-1}
1	12	94.98	13.23	11	95.94	13.12	8	97.47	5.56
2	12	86.63	6.23	11	86.26	5.36	9	87.42	10.14
3	22	83.01	8.69	22	83.03	9.08	20	88.79	8.46
4	8	88.85	7.70	7	87.33	4.91	9	91.72	9.70
T-Test	1 v. (2, 3 + 4) 3.36, 52df, p<0.001			1 v. (2, 3 + 4) 3.24, 49df, p<0.001			1 v. (2, 3 + 4) 2.44, 44df p<0.01		

Notes to Table 8.2.1
The samples are presented for three time intervals. The first dry season figures are after one poor rainfall year. The second figure is for the middle of the subsequent (poor) rainfall year. The final figure is the the dry season after a further rainy season, which had provided good rains and a tolerable crop (though somewhat affected by army worm and 'locust' [actually *Ruspolia differens*] infestation).

Data presented is for the reference month, or within two months of that date.

Data are presented solely for children above two years of age, as between this age and ten years old there are no trends in weight-for-age with age in this particular population (see Methods Chapter).

There are no children in households outside of wealth categories one and two currently in the sandveld population (see Methods Chapter for explanation).

Economic differentiation shows significant relationships with the anthropometric variable 'weight-for-age'. Importantly, contrasting relationships are seen between the sandveld and boundary populations, on the one hand, where poorer anthropometric status is presented by children in the wealthiest category, and the opposite pattern found in the clayveld population where the wealthiest population sector had the heaviest children for their age (Table 8.2.1). Furthermore, the nature and extent of differentiation has varied somewhat, though marginally, through two years of monitoring. This is important to document since Tomkins *et al.* (1986b), have recently shown that socio-economic nutritional differentials can be much more marked in some seasons than others.

The relative nutritional status of children in two kinds of female-headed households is considered in Table 8.2.2, in comparison to those that are male-headed. Although the data are unsatisfactory in terms of sample size and in the representativeness of all population categories, there does appear to be a systematic improvement in child nutritional status in households without resident men, both where the man is away working (and irrespective of whether the household is relatively wealthy or poor), and especially where the household is entirely managed by a woman (a widow). (Table 8.2.2.)

Table 8.2.2: Weight-for-Age Status of Children in Male versus Female-Headed Households

Part 1: Sandveld Sample

	Male-Headed			Man Absent			Female-Headed		
	n	mean	σn^{-1}	n	mean	σn^{-1}	n	mean	σn^{-1}
Wealth:									
1	12	81.83	8.09	0	-	-	0	-	-
2	0	-	-	3	95.77	9.00	0	-	-
Total:	12	81.83	8.09	3	95.77	9.00	0	-	-

Part 2: Boundary Sample

	Male-Headed			Man Absent			Female-Headed		
	n	mean	σn^{-1}	n	mean	σn^{-1}	n	mean	σn^{-1}
Wealth:									
1	5	76.32	6.88	5	94.94	20.16	3	88.50	5.07
2	0	-	-	2	88.35	7.71	0	-	-
3	3	83.03	5.81	5	87.18	6.52	5	92.88	14.16
4	13	88.70	12.53	0	-	-	0	-	-
Total:	21	84.94	11.63	12	90.61	13.54	12	92.02	12.11

Part 3: Clayveld Sample

	Male-Headed			Man Absent			Female-Headed		
	n	mean	σn^{-1}	n	mean	σn^{-1}	n	mean	σn^{-1}
Wealth:									
1	6	94.80	13.56	2	98.35	16.33	4	93.58	15.39
2	7	89.09	5.74	5	83.2	5.67	0	-	-
3	16	83.58	8.70	6	81.5	9.31	0	-	-
4	6	85.40	4.79	2	99.2	3.82	0	-	-
Total:	35	86.92	9.34	15	86.67	10.86	4	93.58	15.39
Grand Total:	**68**	**85.41**	**9.95**	**30**	**89.16**	**11.86**	**12**	**92.02**	**12.11**

Notes to Table 8.2.2
The distribution of male-headed, male absent and female-headed households was approximately equal by household economic category in the boundary and clayveld (though not in sandveld), even if the numbers of children with weight-for-age data in the September timeline is often uneven. Problems with the sandveld data are discussed in the Methods Chapter; the situation in this analysis is further weakened as wealth category is entirely compounded by male labour migrancy.

Households where the man is basically absent (ie. a labour migrant) have slightly heavier children than those where he remains present (t= 1.6, 96df, p= 0.05, approx.). Where the household is female headed (in all cases these were widows without powerful sons), the children are substantially heavier for their age (t= 2.02, 78df, p(0.025) than those in households headed by a present man.

Having considered contrasts in the social status of households (alongside simple economic differentiation), I now draw attention to the effects of social relations within households on anthropometric differentials (Table 8.2.3).

Table 8.2.3: Weight-for-Age and Lineage Status of Children within Households

	Boundary Population						Clayveld Population					
	Patrilineal			Outsider			Patrilineal			Outsider		
Wealth:	n	mean	σn^{-1}	n	mean	σn^{-1}	n	mean	σn^{-1}	n	mean	σn^{-1}
1	7	90.3	18.4	6	81.6	9.8	11	93.9	13.3	1	106.6	-
2	2	88.4	7.7	0	-	-	9	84.9	9.0	3	91.9	5.4
3	12	88.2	10.6	1	91.0	-	17	83.8	5.7	5	80.4	7.9
4	10	91.3	13.1	3	80.0	5.0	8	88.9	7.7	0	-	-
Tot	31	89.7	12.8	10	82.1	8.3	45	87.4	10.1	9	87.2	11.1

Boundary Patri. v Outsider:
$t = 1.72$, 39df, $p<0.05$

Notes to Table 8.2.3
Children were divided into two categories according to their relationship to the household-head; those who were the children of wives or son's wives (classified as 'patrilineal'), and those who were children of other relatives (including fictive), and especially the illegitimate children of daughters of the household-head or his sons (all classified as 'outsiders').

Outsider children made up 21% of the children between two and ten years on clayveld and 26% in the boundary population. They were therefore slightly under-represented in the weight-for-age analysis, due to less information on their precise birthdates, but the number included was not statistically significantly less. One of the 93 children in the boundary sample was of unknown relationship to the household head.

Unfortunately there were insufficient 'outsider' children in sandveld to make analysis of that data useful.

Apparently children in households that are outside of the direct patri-lineage relations (upon which the household sits uneasily astride), are disadvantaged in the boundary population but not the clayveld population. In this boundary population it appears that weight-for-age status does not vary with economic status between children belonging to the household patrilineage, or for outsiders; rather the lower mean anthropometric status of children in wealthier households in this population appears actually to be a function of the fact that there are more of the small outsider children in the richer households. In clayveld, in contrast, such as the data are, anthropometric status declines with poverty in both patrilineage members and outsider children (Table 8.2.3).

Nutritional Seasonality and Household Economic Status

Seasonality of weight gain has been shown to be marked in both the sandveld and clayveld populations, but the patterns are opposite directions in the two sub-samples (Chapter Five, Section 5.2). Boundary populations show little seasonality. This section now examines whether households of different wealth status show equal nutritional seasonality. Unfortunately there is insufficient data to test this for the sandveld population, so the analysis can be presented only for clayveld (Table 8.2.4).

Weight gain velocity is used for this analysis as it was found the most sensitive indicator of seasonal changes in nutritional status in Chapter Five, and also by Bairagi (1987), with Bangladesh data.

Table 8.2.4: Weight Velocity Seasonality on Clayveld
One to Seven Year Olds

	Hot Dry Season						Rainy Season					
	Paired Data			Overall Data			Paired Data			Overall Data		
Wealth	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}	n	mean	σ_{n-1}
1	7	3.26	4.58	10	0.60	5.78	7	2.91	5.66	11	3.57	4.59
2	10	0.62	2.01	12	0.77	2.18	10	2.64	2.85	15	2.88	3.09
3	21	0.31	3.99	23	0.15	3.84	21	4.04	2.50	24	4.14	2.41
4	8	3.15	3.09	9	3.20	2.89	8	2.55	4.67	8	2.55	4.67

Notes to Table 8.2.4
The measurements are weight change velocities (kg/annum) calculated using the same methods as the overall nutritional seasonality study described in Chapter Five, Section 5.2. Children aged one to seven years only are included as NCHS weight gain velocity between these ages remains nearly constant for both sexes (2.2/kg/annum).

The hot dry season data is almost entirely based around weight change of children between September and November 1986, but a few measures are derived for changes between July and November, and between July and September, as all this period was the later (hot) dry season.

The rainy season data is entirely derived from weight changes between November 1986 and January 1987.

Paired data refer to when there is both a dry season and subsequent rainy season data point for a single child. Overall data includes weight velocities recorded for one or other time interval only. This was due to failure to weigh (due to child absence) and cases where children crossed the one year and seven year time intervals between weighings.

The analysis of weight velocity by wealth is essentially indecisive partly through small sample sizes (Table 8.2.4). All wealth categories except the poorest demonstrate the same seasonality pattern in growth velocity as seen in the population as a whole: weight loss in the hot dry season and weight gain during the rains. However, the nine children in the poorest households do not show the expected weight loss during the hot dry season, a time of elevated morbidity (Chapter Six) and 'relish' food stress (Chapter Four) in this population. If weight velocities are only considered for cases of paired weighings in both the hot dry and rainy season, a different pattern is seen amongst the children in the wealthiest households, who now appear to maintain weight gain during the hot dry season. Though such greater growth security in wealthier children could conceivably be related to the predicted better access of the wealthy to purchased relish items at this time, existing data quality limits drawing any conclusions.

Drought Vulnerability to Nutritional Decline

It has been shown that the most economically drought-vulnerable population in this study is that of clayveld, and that, in contrast to the sandveld and boundary populations, children under ten declined significantly in status during the drought period monitored (see Chapter Five, Section 5.3).

Although poorer people in the clayveld undoubtably suffered greater economic hardship during the drought in question, as indeed would be expected, their children did not show greater rates of weight loss than did the children in wealthier households (Table 8.2.5). The differential in weight-for-age was maintained between the economic groups, however. Since functional impairment increases exponentially with falling weight-for-age status (Chapter Seven, Section 7.2), this equal decline masks an unequal impact.

Table 8.2.5: Economic differentiation and declining anthropometric status in the 1986-8 drought (clayveld sub-sample only)

Wealth	January 1987			January 1988			Decline in
	n	Wt/age	σn^{-1}	n	Wt/age	σn^{-1}	Wt/Age status
1	6	97.5	11.82	6	92.1	8.71	- 5.4
2	9	86.2	5.84	9	82.7	5.64	- 3.5
3	12	83.8	10.03	12	79.3	7.32	- 4.5
4	5	87.9	6.15	5	82.2	9.7	- 5.7

Wealth	N children	Improved weight-for-age Jan 87-Jan 88	Declined in weight-for-age Jan 87-Jan 88	Percentage losing weight
1	6	1	5	83
2	9	1	8	89
3	12	2	10	83
4	5	2	3	60

Notes to Table 8.2.5;
Anthropometric measures and wealth categories defined as above

These measures compare rainy season at end of first drought year, with the rainy season a year later that ends the drought; for more detail see Chapter Five, Section 5.3.

The numbers changing in weight-for-age status are for the same children and time period as the mean changes in status.

The education (Table 8.2.6) and religion (Table 8.2.7) of the woman managing the kitchen have little effect on the anthropometric status of the children in those domestic units; none of the observed differentials are statistically significant.

Table 8.2.6: Maternal Education and Child Anthropometric Status (clayveld sub-sample only)

Educ	n	Ht/age	σ_{n-1}	n	Wt/age	σ_{n-1}	n	Wt/Ht	σ_{n-1}
6 + yrs	11	94.38	3.48	11	88.40	11.28	14	98.99	8.05
3-5 yrs	14	93.90	2.99	14	83.94	5.62	24	94.55	5.64
1-2 yrs	18	95.13	4.18	18	89.40	12.56	25	96.38	6.58
illit.	6	96.27	4.48	7	88.59	9.00	20	98.42	6.29

Notes to Table 8.2.6:
Anthropometric measures and educational codes as above.

Maternal education actually refers to the status of the woman managing the domestic unit (kitchen), of which the child is a part. This is usually, but not always the mother. She may occasionally be present but not responsible for the kitchen/child, or be absent or dead.

Table 8.2.7: Maternal Religion and Child Anthropometric Status (clayveld sub-sample only)

Religion	n	Ht/age	σ_{n-1}	n	Wt/age	σ_{n-1}	n	Wt/Ht	σ_{n-1}
Mission	20	94.42	3.64	19	87.94	12.33	31	97.49	6.22
Tradit	12	93.85	2.96	13	85.66	9.45	29	95.79	7.81
Zionist	8	96.49	2.81	8	89.66	8.34	10	96.72	6.32
Apostolic	9	94.10	5.30	10	83.23	8.01	11	95.15	5.84

Notes to Table 8.2.7:
For definition of religious categories, see Table 8.0.1.

As in the case of maternal education (Table 8.2.6), maternal religion refers to that of the woman managing the domestic unit of which the child is a member irrespective of whether she is the biological mother.

8.3 Differentials in Morbidity and Treatment

This section examines for morbidity and treatment differentials with varying socio-economic status. With such marked differentials in infant mortality (8.4) but such minimal effects on anthropometric status (8.2), disease vulnerability is hypothesised to be partly responsible for differences in mortality; alongside, in clayveld, the effects of birthweight (8.1).

Morbidity Differentials

In the boundary population overall morbidity is only marginally worse in the poor households, principally reflecting more ENT and 'sore eyes' morbidity (Table 8.3.1). Diarrhoeal morbidity is perhaps actually worse amongst the children in wealthy households in this ecological zone. In contrast, in the clayveld population there is markedly lower morbidity in the wealthiest households, largely reflecting much less diarrhoea (Table 8.3.2).

Table 8.3.1: Economic Differentiation and Morbidity Boundary sub-sample

Wealth	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
1	182	67	36.8	20	11.0	31	17.0	8	4.4
2	27	13	48.1	8	29.6	3	11.1	1	3.7
3	155	62	40.0	15	9.7	36	23.2	5	3.2
4	175	83	47.4	16	9.1	37	21.1	18	10.3
1+2 v 3+4 χ^2=		1.68	p<0.2	2.10	p<0.2	2.75	p<0.1	1.62	p<0.2

Notes to Table 8.3.1
Numbers refer to weekly recall data from mothers on a bimonthly basis between mid 1986 and mid 1988; see detailed description in General Methods and Chapter Six. Child-weeks refers to the number of samples n weeks times n children). All morbidity between birth and aged ten is included.

ENT means ear, nose and throat infections.

Although there was not statistically significantly greater 'sore eyes' in wealth categories 3+4 combined than in 1+2, wealth category four alone versus the other categories was χ^2 8.77, p<0.01

Table 8.3.2: Economic Differentiation and Morbidity Clayveld sub-sample

Wealth	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
1	168	53	31.5	7	4.2	23	13.7	8	4.8
2	156	70	44.9	29	18.6	26	16.7	6	3.8
3	305	129	42.3	48	15.7	41	13.4	15	4.9
4	141	63	44.7	13	9.2	25	17.7	10	7.1

Notes to Table 8.3.2:
Wealth category one showed lower diarrhoea than the other categories pooled (χ^2, 1df, 13.8, p<0.001), and consequently less morbidity over-all (χ^2, 1df, 7.79, p<0.01). This is not a function of the group of wealthy households relying upon bore-hole water and using pit latrines, as diarrhoeal morbidity in the wealthiest households is the same in those using and not using borehole water and those using pit latrines (see Chapter Six, Section 6.3)

Since the nutritional status of children varied with their relationship to the household head (in the case of the boundary sample), and whether they were in a female or male headed household (Section 8.2), I now examine whether similar differentials are reflected in morbidity. First, I examine whether levels of morbidity in 'outsider' children are worse (Table 8.3.3), examining both the situation in households of wealth category one, in which most of them reside, and then in other households. This also provides an important comparison between 'insider' patrilineally-related children in the wealthiest households, versus children in the poorer households.

Table 8.3.3:
Lineage Status of Children Within Households and Morbidity
Boundary sub-sample

	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
Wealth 1									
Patrilin	78	20	25.6	6	7.7	8	10.3	2	2.9
Outsider	102	47	46.1	14	13.7	23	22.5	6	5.9
Pat v Out χ^2		7.9,	$p<0.01$	1.6,	$p=0.2$	4.7,	$p<0.05$	samp	small
Wealth 2, 3 + 4									
Patrilin	353	158	44.8	39	11.0	76	21.5	24	6.8
Outsider	6	0	0	0	0	0	0	0	0

Notes to Table 8,3,3
The statistical analysis first compares closely patrilineally descended 'insider' children, with 'outsider' children in wealth category one only; where most of these children live, and the only wealth category where there is sufficient data for statistical testing. These data are presented in the Table.

Next I test the 'insider' children of wealth category one, with the 'insider' children of the other wealth categories. Overall morbidity is consderably lower in children in the wealthiest households (χ^2= 9,6 (p<0,01), diarrhoeal morbidity a little lower in wealthier households (non-signif), ENT morbidity much lower in wealthier households (χ^2= 5,2 (p<0,05), and sore eyes possibly also lower (χ^2= 2,0 (p<0,2).

Levels of child morbidity who are 'outsiders' in their households (according to patrilineal descent) is considerably higher than that amongst 'insider' children (Table 8.3.3). This is true with overall morbidity, and with each of the most significant morbidity categories. Since these 'outsider' children are concentrated in the wealthiest households, this explains why overall levels of morbidity are as high (or higher) in the wealthy in the boundary population; in fact core patrilineally descended children in these wealthy households had considerably lower morbidity than the 'insider' children in the poorer households (Table 8.3.3). This result therefore reinforces the observation that lower morbidity amongst wealthier children may be an important contribution to better welfare status (see Table 8.3.2 for the result in the clayveld sample).

Household headedness appears to have a negligible effect upon morbidity, a result in contrast to the marked relationships found with anthropometric status (Table 8.3.4). There are suggestions that diarrhoeal morbidity may be lower in male-headed households, whilst ENT and sore eyes morbidity is actually higher in male-headed households, but no results reach the 5% level of statistical significance.

Table 8.3.4: Male and Female Headedness of Household and Morbidity
Boundary sub-sample

Wealth	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
Male-Head	323	140	43.5	29	9.0	69	21.4	24	7.4
Male Abs.	156	60	38.5	22	14.1	32	20.5	3	1.9
Female H.	60	25	41.7	8	13.3	6	10.0	5	8.3
Male v Female χ^2		0.85	N.S.	3.20	$p<0.1$	1.15	$p<0.3$	3.22	$p<0.1$

Notes to Table 8.3.4
For detailed definitions of household types (male headed, *de facto* female-headed [male head absent], and entirely female-headed - all widows), see notes to Table 8.0.1.

Table 8.3.5: Maternal Education and Morbidity
Boundary sub-sample

Educat	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
6+ yrs	35	19	54.3	12	34.3	4	11.4	2	5.7
3-5 yrs	176	72	40.9	16	9.1	35	19.9	6	3.4
1-2 yrs	75	22	29.3	4	2.5	9	12.0	5	6.7
illit.	165	66	40.0	14	8.5	38	23.0	12	7.2
0-2 v 3-6+ Yrs, χ^2		1.95	$p<0.2$	4.07	$p<0.05$			2.37	$p<0.2$

Notes to Table 8.3.5
For statistical analysis samples are pooled for the higher educated (3-5 and 6+ years) versus the illiterate women and those with 1-2 years of education.

Table 8.3.6: Maternal Education and Morbidity
Clayveld sub-sample

Educat	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
6+ yrs	122	47	38.5	12	9.8	22	18.0	9	7.4
3-5 yrs	198	80	40.4	30	15.2	30	15.2	9	4.5
1-2 yrs	203	78	38.4	28	13.8	21	10.3	9	4.4
illit.	168	85	50.6	19	11.3	31	18.5	10	6.0

Notes to Table 8.3.6:
Maternal education and morbidity defined as above

Illiterate women managing the kitchen are associated with higher morbidity (χ^2, 1df, 6.8, $p<0.01$).
The lower diarrhoea amongst children in the highest educated womens' kitchens is not statistically significant.

The impact of maternal educational attainment on morbidity appears to show contradictory results between the boundary and clayveld populations. In clayveld the households with the most educated women have lower child morbidity especially with diarrhoea (Table 8.3.6). However, in the boundary sample the opposite result is recorded (Table 8.3.5), so that it is more educated women who reported sicker children. In clayveld, illiterate womens' children were reported to be more often unwell, whilst in the boundary population the results suggest that there may be greater overall morbidity in the children in households managed by more highly educated women. However, even in the boundary population there is higher morbidity with sore eyes in the children in households with less educated women. Yet the overall differences in morbidity levels with variation in maternal education are not dramatic. Next, I examine the effects of maternal religion upon child morbidity (Tables 8.3.7 and 8.3.8).

Table 8.3.7: Maternal Religion and Morbidity
Boundary sub-sample

Relig.	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
Mission	220	96	43.6	31	14.1	48	21.8	15	6.8
Tradit	137	58	42.3	10	7.3	25	18.2	6	4.4
χ^2				3.83, $p<0.05$					

Notes to Table 8,3,7
The nature of maternal religion categories is discussed in Table 8,0,1

Table 8,3,8: Maternal Religion and Morbidity
Clayveld sub-sample

Relig.	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
Mission	250	96	38.4	24	9.6	45	18.0	8	3.2
Tradit	236	104	44.1	34	14.4	28	11.9	12	5.1
Zionist	102	46	45.1	11	10.8	24	23.5	8	7.8
Apost	93	43	46.2	23	24.7	12	12.9	6	6.5

Notes to Table 8,3,8:
Data and categories as defined above

Elevated diarrhoea amongst Apostolics and ENT amongst Zionists are statistically significant compared to the rest of the population; χ^2, 1df, 11,57, $p<0,001$ and χ^2, 1df, 5,05, $p<0,05$, respectively.

Apostolic church members, whose children have higher infant mortality (see Table 8.4.9), also have higher diarrhoea in the under-ten age group (Table 8.3.8). It is not known whether this higher morbidity is also found in the under one year olds, because there is insufficient data. Zionists experience marginally higher ENT problems than the children cared for by women of other religious affiliation. In the boundary sample - but not that of clayveld - children cared for by women affiliated to mission churches experience higher diarrhoea. This may be due to the larger number of 'outsider' children in those particular households that are Mission Christian.

I now examine data for the effect of family size on morbidity levels (Tables 8.3.9 and 8.3.10).

Table 8.3.9 Family size effect upon morbidity
Boundary sub-sample

Family Size	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
1 and 2	38	14	36.8	3	7.9	6	15.8	4	10.5
3	21	11	52.4	2	9.5	7	33.3	0	0
4	116	44	37.9	8	6.9	20	17.2	8	6.9
5	132	55	41.7	15	11.4	32	24.2	8	6.1
6+	232	101	43.5	31	13.3	42	18.1	12	5.2

Notes to Table 8.3.9:
Family-size means the number of under ten year olds living in the household, whatever their actual relationship to other household members.

The only area where there appeared to be a systematic effect of family size on morbidity was in the case of diarrhoea, where households with 5, 6 or more members had nearly twice the level of morbidity as the smaller families (χ^2 = 3.28, p<0.1 N.S.).

Table 8.3.10 Family size effect upon morbidity
Clayveld sub-sample

Family Size	child-weeks	morbidity n	morbidity %	diarrhoea n	diarrhoea %	ENT n	ENT %	Sore eyes n	Sore eyes %
1 and 2	128	43	33.6	14	10.9	23	20.0	6	4.7
3	140	65	46.4	15	10.7	27	19.3	8	5.7
4	295	136	46.1	46	15.6	43	14.6	17	5.8
5+	204	73	35.8	22	10.8	23	11.3	9	4.4

Notes to Table 8.3.10:
Family-size means the number of under ten year olds living in the household, whatever their actual relationship to other household members.

Family sizes (n, under ten) of 1, 2 and 3 show higher ENT than those of 4 and above (χ^2, 1df, 14.18, p<0.001). Family sizes of 1 and 2, and of 5 and above, both show lower morbidity than the intervening sizes (χ^2, 1df, 6.41 and 6.14, respectively, each p<0.02).

The relationships between family size and morbidity appear generally weak.[23]

Treatment Responses to Morbidity

Although some differences between anthropometric status and morbidity levels were found related to differentiation, these do not appear sufficient to explain the large mortality differentials reported in Section 8.4. This section therefore explores whether there is a differential response to morbidity in terms of treatment sought.

Table 8.3.11: Economic Differentiation and Response to Morbidity Boundary sub-sample

Wealth	n morb	no treat. n	no treat. %	home remedy n	home remedy %	purch med n	purch med %	oral re-hyd n	oral re-hyd %[1]	VHW n	VHW %	clinic n	clinic %	hosp. n	hosp. %	church n	church %
1	67	27	40	4	6	3	4	1	5	13	19	20	29	0	0	0	0
2	13	5	38	1	8	4	31	0	0	0	0	0	0	3	23	0	0
3	62	23	37	2	3	9	15	1	9	11	18	10	16	0	0	0	0
4	83	41	40	6	7	9	11	4	25	5	6	10	12	0	0	7	8

Notes to Table 8.3.11:
Response to morbidity data is derived from the same weekly recall data as the morbidity material; for further information on the method consult General Methods (Chapter Two) and Chapter Six. No treatment refers to no prescribed action, VHW refers to Village Health Worker, the other treatment categories are self-explanatory.

1: the percentage use of ORS is the proportion of recorded cases of diarrhoea treated in this manner, rather than a percentage of overall morbidity, as in the case of the other treatments.

The use of all 'western health care' (VHW, clinic, hospital, oral rehydration solution) is greater in wealth categories one plus two, than in categories three plus four (χ^2 = 6.59, p<0.02); though ORS is used more in poorer households, but the sample size is too small to test statistically.

Table 8.3.12: Economic Differentiation and Response to Morbidity Clayveld sub-sample

Wealth	n morb	no treat. n	no treat. %	home remedy n	home remedy %	purch med n	purch med %	oral re-hyd n	oral re-hyd %[1]	VHW n	VHW %	clinic n	clinic %	hosp. n	hosp. %	church n	church %
1	54	18	33	9	17	13	24	1	14	2	4	10	19	4	7	0	0
2	70	27	39	13	19	2	3	2	7	4	6	11	16	0	0	14	20
3	129	56	43	15	12	27	21	5	10	6	5	22	17	1	1	6	5
4	63	21	33	10	16	3	5	4	31	9	14	17	27	1	2	3	5

Notes to Table 8.3.12:
For morbidity categories see Table 8.3.11.

The high level of purchased medicines in wealth category 3 was caused by a single woman who purchased medicine 13 times. Nevertheless wealth category one bought more medicines per morbid case than the other categories pooled (χ^2, 1df, 5.2, p<0.05). Oral rehydration therapy, the village health worker and the clinic were used most frequently by the poorest households. The sample size is too small to test for statistical significance with the ORS, but the use of the VHW is statistically significant (χ^2, 1df, 7.39, p<0.01), though the increased use of the clinic only χ^2, 1df, 3.21, p<0.1.

The four visits to the hospital in wealth category one were for not very serious measles when the mother was at hospital herself for another purpose, and therefore do not in themselves show that hospital is more frequently resorted to by the wealthy in this population. The high attendance of wealth category two at church is due to the presence of two active Apostolic households in this sub-sample.

Markedly different relationships between wealth and response to morbidity were found between the populations of boundary and clayveld soils. In the clayveld population the poorest made much fuller use of the (free) western health care (Table 8.3.12). In contrast, in the boundary population western health treatment is used more frequently for the children in the wealthier households (Table 8.3.11). In the clayveld population - but not that of the boundary zone - the wealthiest households buy medicines much more frequently for their sick children than do the poor.

I now examine whether there are treatment differentials in relation to variations in domestic organisation (Table 8.3.13).

Table 8.3.13: Relationship of Child to Household-Head and Response to Morbidity, Boundary sub-sample

Relat	n morb	no treat. n	no treat. %	home remedy n	home remedy %	purch med n	purch med %	oral re-hyd n	oral re-hyd %¹	VHW n	VHW %	clinic n	clinic %	hosp. n	hosp. %	church n	church %
Patrilin	178	76	43	10	6	25	14	5	11	18	10	27	15	3	2	7	4
Outsider	48	20	42	3	6	0	0	1	7	11	23	13	27	0	0	0	0

Notes to Table 8.3.13
Relationship of child to household head is defined as direct patrilineal (child or son's child) or 'outsider', see earlier definitions.

Children in direct patrilineal relationship to the household head have medicine purchased for them more often than 'outsiders'; $\chi^2= 7.6$ $p<0.01$.

'Outsider' children are more frequently given western medical care (clinic, VHW, hospital and ORS) than those that are patrilineally related to household heads ($\chi^2= 8.32$, $p<0.01$).

Table 8.3.14: Household Head Type and Response to Morbidity Boundary sub-sample

Headed	n morb	no treat. n	no treat. %	home remedy n	home remedy %	purch med n	purch med %	oral re-hyd n	oral re-hyd %¹	VHW n	VHW %	clinic n	clinic %	hosp. n	hosp. %	church n	church %
Male Head	140	66	47	11	8	14	10	4	14	16	11	19	14	0	0	7	5
Male Abs	60	20	33	2	3	11	18	1	5	8	13	13	22	3	5	0	0
Female Hd	25	10	40	0	0	0	0	1	13	5	20	8	32	0	0	0	0

Notes to Table 8.3.14
Household-headedness as defined and discussed in Table 8.0.1.

Female headed households, and households where the male household head was absent used western medical treatments (clinic, VHW, hospital and ORS) more frequently than do male-headed households ($\chi^2= 7.58$, $p<0.01$).

Female-headed households respond to morbidity with greater use of western medical facilities, than do the male headed households (Table 8.3.14). Children in boundary zone households that are 'outsiders' have medicine purchased for them more often that those that are patrilineally related to the household head (Table 8.3.13). This explains why wealthy households do not buy more medicines than the poorer in the boundary population as is the case in clayveld. In fact wealthy households do buy more for their 'insider' children, but less for the 'outsider' children. It is because outsider children are attached to wealthy households in large numbers that on average there are not more medicines purchased per child in these households.

It had been expected that 'outsider' children would receive less western medical care than 'insiders', but in fact the opposite was the case (Table 8.3.13). This is presumably a function of higher morbidity in those children (see above). This factor also means that ordinary insider children in households do not get greater western medical care in wealthy households in the boundary zone (as had been suggested in Table 8.3.11). In fact in both clayveld and sandveld the 'insider' children in households that are wealthy receive less western medical treatment than amongst the poor (cf. Table 8.3.12 for clayveld).

I now turn to analysis of how maternal education effects health care usage in response to child morbidity (Table 8.3.15).

Table 8.3.15: Maternal Education and Response to Morbidity
Boundary sub-sample

Educ.	n morb	no treat.		home remedy		purch med		oral re-hyd		VHW		clinic		hosp.		church	
		n	%	n	%	n	%	n	%'	n	%	n	%	n	%	n	%
6+ yrs	20	6	30	2	10	5	25	0	0	1	5	2	10	3	15	0	0
3-5 yrs	68	32	47	2	3	8	12	1	6	11	16	14	21	0	0	0	0
1-2 yrs	22	9	41	3	14	4	18	1	25	2	9	3	14	0	0	0	0
illit	67	33	49	4	6	7	10	1	7	8	12	14	21	0	0	0	0

Notes to Table 8.3.15:
Education and response to morbidity categories as above

Illiterate women take no response to morbidity more often than the other women, but the result does not even approach statistical significance (χ^2= 0.7).

Western medical health care (clinic, VHW, ORS and hospital) is used more frequently by more educated women (3 years of schooling and over), than by less educated women (0-2 years schooling); but the result is not statistically significant; χ^2= 1.06, p<0.4.

Table 8.3.16: Maternal Education and Response to Morbidity
Clayveld sub-sample

Educ,	n morb	no treat, n	%	home remedy n	%	purch med n	%	oral re-hyd n	%¹	VHW n	%	clinic n	%	hosp, n	%	church n	%
6+ yrs	47	18	38	9	19	12	26	2	17	5	11	12	26	0	0	1	2
3-5 yrs	80	26	33	14	18	20	25	5	17	4	5	13	16	0	0	3	4
1-2 yrs	78	30	39	10	13	7	9	0	0	4	5	16	21	5	6	9	12
illit	85	31	37	10	12	4	5	4	21	4	5	18	21	1	1	10	12

Notes to Table 8,3,16;
Education and response to morbidity categories as above

Women of better educated categories (3-5 and 6+ yrs education) purchased more medicine than the less educated (χ^2, 1df, 19,2, p<0,001), The church members who actively use church treatments actually tend to be the less educated (χ^2, 1df, 7,13, p<0,01),

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More educated women purchased medicine more frequently in response to child morbidity in both boundary and clayveld populations, but the effect was only statistically significant in clayveld. There is little difference in the use of western health care facilities between women with greater and lesser levels of education, though in the boundary population there is a weak suggestion that the better educated make greater use of such facilities.

I now turn to examination of the effect of maternal religion on response to morbidity; pertinent since certain religious groups prohibit western medical treatment, and experience higher mortality (Tables 8.3.17 and 8.3.18).

Table 8.3.17: Maternal Religion and Response to Morbidity
Boundary sub-sample

Relig	n morb	no treat, n	%	home remedy n	%	purch med n	%	oral re-hyd n	%¹	VHW n	%	clinic n	%	hosp, n	%	church n	%
Mission	98	35	36	6	6	12	12	3	10	21	21	20	20	0	0	0	0
Tradit	58	34	59	3	5	4	7	0	0	5	9	7	12	0	0	0	0
χ^2		7,8 p<0,01				1,1, p<0,3				All western: 9,3, p<0,01							

Notes to Table 8,3,17;
Definitions of religious categories and responses to morbidity as above

Unfortunately there is a lack of data for Zionist and Apostolic households in this population,

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Maternal religion has some marked impacts on response to morbidity. In the boundary population, the mission Christian mothers treat a greater proportion of all morbidity, especially using western medical care, than do the mothers who claim to be 'traditionalists' (Table 8.3.17). In the clayveld population, however, there is no difference in the proportion of morbidity that is treated, or the kind of treatment supplied by women in these two religious categories (Table 8.3.18).

Table 8.3.18: Maternal Religion and Response to Morbidity
Clayveld sub-sample

Relig	n morb	no treat.		home remedy		purch med		oral re-hyd		VHW		clinic		hosp.		church	
		n	%	n	%	n	%	n	%'	n	%	n	%	n	%	n	%
Mission	96	44	46	12	13	10	10	2	8	5	5	18	19	4	4	3	3
Tradit	104	34	33	19	18	12	12	7	21	8	8	25	24	1	1	0	0
Zionist	46	17	37	7	15	16	35	3	27	6	13	6	13	0	0	1	2
Apost	43	17	40	4	9	3	7	0	0	2	5	1	2	0	0	17	40

Notes to Table 8,1,3,18:
Definitions of religious categories and responses to morbidity as above
The high level of purchasing of medicines by Zionists was due to one woman purchasing medicine 13 times,

Apostolics use fewer home cures (χ^2= 1,12, p<0,3), purchase less medicines (χ^2= 2,2, p<0,2), and use less western medical care - ORS, clinics, VHW and hospitals - (χ^2= 13,15, p<0,001), However, Apostolics make greater use of church cures (χ^2= 78,2, p<0,001; but note that church cures are so rarely used in the non-Apostolic households that the expected value in the Apostolic households is only 3,1, and so less than the legitimate minimum value of '5'),

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The large differential in morbidity response with maternal religion in the clayveld sample is seen with women adhering to the Apostolic faith. Though both members of the Apostolic and Zionist sects formally hold beliefs that only church treatment (prayer and holy water) is effective, they actually provided a wide variety of treatments for their children when sick. Furthermore, it was noted that in the case of the women in this particular sample, Zionist adherents provided a similar treatment regime to the other population sectors (despite normative statements to the contrary). It was the Apostolic women whose children were given markedly different treatment, in particular very minimal western health care (Table 8.3.18).

It was noted in the introductory review of the literature that socio-economic differentials are often reflected in differences in family size, with this having independent effects on morbidity. Tables 8.3.9 and 8.3.10 have examined how family size effects child morbidity; this section now examines whether family size is linked with treatment differentials.

Table 8.3.19: Family size and response to morbidity Boundary sub-sample

Family Size	n morb	no treat. n	no treat. %	home remedy n	home remedy %	purch med n	purch med %	oral re-hyd n	oral re-hyd %'	VHW n	VHW %	clinic n	clinic %	hosp. n	hosp. %	church n	church %
1 and 2	14	7	50	0	0	2	14	0	0	1	7	4	28	0	0	0	0
3	11	4	36	1	9	1	9	0	0	2	18	0	0	0	0	0	0
4	44	17	39	4	9	3	7	1	13	5	11	9	20	0	0	0	0
5	55	15	27	3	6	11	20	4	27	9	16	6	11	0	0	7	13
6 plus	102	51	50	5	5	8	8	1	3	12	12	21	21	3	3	0	0

Notes to Table 8,3,19:
For family-size and response to morbidity categories see above,

The smallest family sizes provided less treatment than all but the largest family size, but the sample is too small to examine statistically. The largest family sizes (six children and over), provided no treatment more often than the other family sizes (χ^2= 5,4, p=0,02). Otherwise there were no systematic differences between family size and morbidity-response,

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Table 8.3.20: Family size and response to morbidity Clayveld sub-sample

Family Size	n morb	no treat. n	no treat. %	home remedy n	home remedy %	purch med n	purch med %	oral re-hyd n	oral re-hyd %'	VHW n	VHW %	clinic n	clinic %	hosp. n	hosp. %	church n	church %
1 and 2	43	22	51	2	5	3	7	1	2	3	7	12	28	0	0	2	5
3	65	28	43	9	14	3	5	1	2	4	6	6	9	1	2	14	22
4	136	39	29	21	15	31	23	9	7	8	6	29	21	1	1	6	4
5 plus	73	31	43	15	21	8	11	1	1	6	8	11	15	4	6	1	1

Notes to Table 8,3,20:
For family-size and response to morbidity categories see above,

Family size 1+2 is slightly more likely to do nothing in response to morbidity than larger families (χ^2 1df, 3,75, p almost equal to 0,05, Family sizes of 4 and 5 and above versus those of 1,2 and 3 buy more medicines (χ^2, 1df, 10,04, p<0,01), The difference in regard to church attendance is due to two families falling in that category, rather than any possible causal relationship,

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Increases in family size (as assessed here) do not lead to clear general differences in the response to morbidity (Tables 8.3.19 and 8.3.20). It might be expected that increasing family size results in declining response to morbidity: both due to increasing wisdom in more experienced women about when to respond (ie. knowing how often not to respond), and also because of time constraint of looking after additional children. But, contrary to expectations, the smallest family sizes did 'nothing' the most often in both the boundary and clayveld populations. This was not because they reported more morbidity which was too minor to be treated: in fact they reported lower morbidity (Tables 8.3.9 and 8.3.10).[24] In the boundary sample, however, the very largest family sizes did show reduced response to morbidity.

Larger families used more purchased medicine per morbid incident per child in the clayveld sample (Table 8.3.20), though not in the boundary sample (Table 8.3.19). I suspect that this is largely due to the effects of economy, whereby it is more efficient to buy medicine when there are many children requiring to use it.[25] The correlation may also be partly a wealth effect, as many purchasing households were both large and wealthy.

8.4: Mortality Differentials

Analysis of socio-economic differentials in mortality is limited due to small sample size for an infrequent event such as mortality; so I am reliant upon retrospective analyses. In the case of economic differentiation - where both the status of each household, and the extent and form of differentiation between the wealthy and poor - has changed during the time period investigated (1950-87), very little can be concluded with such retrospective data. In particular, therefore, it cannot be studied whether poor households are more vulnerable to drought or wet year mortality (cf. Chapter Seven, Section 7.2).

Table 8.4.1: Economic Differentiation and the Infant Mortality Rate

Wealth	1950-1979 n born	n died	IMR	1980-1986 n born	n died	IMR
1	158	12	76	51	1	20
2	47	8	170	32	1	31
3	102	11	108	48	6	125
4	61	8	131	39	8	205
Stat signif	1+2 v 3+4		n.s.	χ^2, 1df. 9.29		$p<0.01$

Notes to Table 8.4.1:
For wealth categories see Table 8.1.1.1 and General Methods Chapter.

IMR is the number of infants who die less than one year in one thousand live births
IMR stayed fairly constant between 1950 and 1979 and then reduced markedly after independence in 1980 (see Section 8.2)

High IMR is seen in wealth category two in the 1950-79 period largely due to the presence of several Apostolic households with higher mortality (see Table 8.1.4.9).

Considered overall there are marked differences in the Infant Mortality Rate in the post-independence period by wealth category, but not in the earlier time period. I now examine whether these differentials are found in both the sandveld/boundary and clayveld sub-samples.

8.4.2: Economic Differentiation and the Infant Mortality Rate
Sandveld and Boundary Sub-Sample

Wealth	1950-1979 n born	1950-1979 n died	IMR	1980-1986 n born	1980-1986 n died	IMR
1 + 2	91	8	88	53	1	20
3 + 4	39	5	128	39	5	128

Notes to Table 8.4.2:
Wealth categories as above, but with 1 + 2 and 3 + 4 pooled to increase sample size.
IMR defined as above

The samples are too small for χ^2 analysis.

Table 8.4.3: Economic Differentiation and the Infant Mortality Rate
Clayveld Sub-Sample

Wealth	1950-1979 n born	1950-1979 n died	IMR	1980-1986 n born	1980-1986 n died	IMR
1	75	4	53	9	0	0
2	39	8	205	21	1	48
3	66	9	136	29	2	69
4	37	6	162	19	7	368

Notes to Table 8.4.3
Categories and definitions as above.

There is no clear relationship between wealth and IMR in the 1950-79 data, due to high mortality in wealth category two, which has many Apostolics (see Table 8.1.4.9), but there is a suggestion that category one has lower IMR than the other three combined (χ^2= 5.33, $p<0.05$)

The post-1980 sample is too small to use χ^2

Table 8.4.4: Economic Differentiation and the Child Mortality Rate

Wealth	1950-1979 n born	1950-1979 n died	Rate/ 1000
1	158	1	6
2	47	3	64
3	102	7	69
4	61	4	66

Notes to Table 8.4.4
Child deaths were those between one and five years as recorded from mothers.

Wealth categories as above

There were only four child deaths pre-1950 and one post 1980 so these periods and their deaths have been excluded.

Wealth category 1 versus 2, 3 + 4 combined has lower child mortality; χ^2 8.41, 1df, $p<0.01$

Marked wealth differentials in Infant Mortality Rate are thus apparent in both population sub-samples since Independence (1980), whereby wealthy households have much lower mortality. I also examined whether there are similar differentials in child mortality, though due to low mortality in this age group (1-5 years) since independence, I am obliged to consider only the 1950-79 period (Table 8.4.4). Though the sample sizes are small, and though many households currently wealth category one may have been poorer in previous years (and vice versa), wealth category one had much lower child mortality than the other populations.

Though there were considerable differences in infant and child mortality rates with economic differentiation, no differences were reported in miscarriages and still births (Table 8.4.5). This may be a result of the poor quality of the data, however.

Table 8.4.5: Economic Differentiation and Miscarriages and Still Births

Wealth	All Years (1935-1986) n pregnancies	n miscarriages and still births	rate/1000
1	226	5	22.1
2	88	1	11.4
3	168	5	29.8
4	103	1	9.7

Notes to Table 8.4.5
Miscarriages and still-births presumably under-recorded in all categories (cf. re-interview data by A. Cornwall, pers. comm. 1989.

Analysis now focuses on the effect of maternal education on levels of infant mortality.

Table 8.4.6: Maternal Educational and the Infant Mortality Rate

Education	1950-1979 n born	n died	IMR	1980-1986 n born	n died	IMR
6+ yrs	27	1	37	26	1	38
3-5 yrs	56	4	71	50	3	60
1-2 yrs	90	9	100	23	3	130
illit	123	20	163	33	8	242

Notes to Table 8.4.6:
Maternal education has a marked impact upon IMR: 1950-1986 pooled by educational categories across years, χ^2, 3df, 12.13, $p<0.01$

Table 8.4.7: Maternal educational status and the Child Mortality Rate

Education	1950-1979 n born	n died	Rate/1000
6+ yrs	27	0	0
3-5 yrs	56	3	54
1-2 yrs	90	6	67
illit	123	4	33

Notes to Table 8.4.7:
Educational categories as above, with the focus on 1950-79 for the reasons explained in Table 8.4.4

Child Mortality Rates are too similar and samples too small to suggest any difference. The only other child death for whom maternal education is known was for an illiterate woman pre-1950

Maternal educational status appears to have a highly significant impact upon infant mortality, but less of an impact upon child mortality (Tables 8.4.6 and 8.4.7). However, maternal education interacts with household wealth in determining mortality differentials (Table 8.4.8), such that the effect of maternal education is much stronger in poorer households; overall wealth and literacy appear to have multiplicative effects on infant mortality.

Table 8.4.8: Maternal Educational Attainment by Household Wealth: and the Infant Mortality Rate

(a) Richest wealth categories only (one and two)

Education	1950-1979 n born	n died	IMR	1980-1986 n born	n died	IMR
6+ yrs	15	1	67	16	0	0
3-5 yrs	40	3	75	23	1	43
1-2 yrs	51	7	137	8	1	125
illit	80	9	113	14	0	0

(b) Poorest wealth categories only (three and four)

Education	1950-1979 n born	n died	IMR	1980-1986 n born	n died	IMR
6+ yrs	12	0	0	10	1	100
3-5 yrs	16	1	63	27	2	74
1-2 yrs	39	2	51	15	2	133
illit	43	11	256	19	8	421

Notes to Table 8.4.8:
Wealth and educational categories as defined as above

Richest wealth categories:
The effect of education is much less marked and not statistically significant

Poorest wealth categories:
Contrasting all the literate pooled versus the illiterate the difference is significant both in the 1980-6 and 1950-79 data (χ^2= 9.79 and 10.51 respectively, both p<0.01). The difference between 1950-79 and 1980-6 is non-significant, despite the fact that mortality appears to have increased per educational/wealth category.

I know examine evidence for mortality differentials with maternal religion.

Table 8.4.9: Maternal Religion and Infant Mortality Rate

Religion	1950-1979 n born	1950-1979 n died	IMR	1980-1986 n born	1980-1986 n died	IMR
Mission	130	15	115	40	3	75
Traditionalist	87	9	103	40	2	50
Zionist	34	2	59	23	1	43
Apostolic	43	5	116	20	5	250

Notes to Table 8.4.9:
Definitions and categories as above.

The samples are too small to test for post Independence mortality differentials with χ^2, but with the binomial test of proportions Apostolic infant mortality rates were higher than those of other women ($p<0.01$).

Table 8.4.10 Maternal Religion and the Child Mortality Rate

Religion	1950-1979 n born	1950-1979 n died	Rate/1000
Mission	130	7	54
Traditionalist	87	5	57
Zionist	34	0	0
Apostolic	43	2	47

Notes to Table 8.4.10:
Categories as above

Tables 8.4.9 and 8.4.10 suggest that there may be marginal effects of maternal religion on mortality. Differences in the Apostolic population should be considered in the light of their reluctance to use western medical treatment (Table 8.3.18).

8.5 Welfare variables in domestic units experiencing an infant death

Characteristics that predispose a woman to experience an infant death may be reflected in the status of the other children under her care, and hence revealed by comparison of those children with other children in the population. In an attempt to identify 'risk' factors at the domestic unit level, this section examines the characteristics of children whose siblings died. Due to the nature of this study it was necessary to examine siblings (and other children under the care/kitchen of that women) subsequent to the death when conditions may or may not be similar to what they were at the time of actual mortality.

Three categories of domestic unit were established: one for those experiencing deaths post-1980 ('recent'), a second for where the deaths were between 1950 and 1979, and the third for those who had not experienced such a death.

Table 8.5.1: Anthropometric Status of Surviving Children of Women with Infant Deaths two to ten years old, clayveld sub-sample

	Ht/Age			Wt/Age			Wt/Height		
	n	mean	σn^{-1}	n	mean	σn^{-1}	n	mean	σn^{-1}
Death:									
1980-87	2	98.6	0.57	2	91.0	10.10	9	99.4	6.94
1950-87	20	95.0	3.81	21	88.1	11.48	40	98.26	5.88
No death	31	94.5	3.61	31	86.4	9.49	49	95.37	7.07

Notes to Table 8.5.1:
For details of measures of anthropometric status see General Methods and Chapter Five

Recent death is the category for cases where the mother/manager of the kitchen they belong to has had an infant (<1 year) death since 1980. Death since 1950 is where there has been an infant death between 1950 and the present (ie. including 1980-87 in this particular Table). No deaths are the other households experiencing no deaths in this interval. Deaths were determined from the reproductive histories of the women managing the domestic unit concerned, and therefore exclude deaths of outsider children in these households. This would be expected to reduce differentials, rather than bias results, but this is nevertheless an important methodological problem.

Ht/Age is better in children in families where there has been a recent infant mortality, but this is not statistically significant (t= 1.54, 31df, p<0.1 nearly p= 0.05; one sample extremely small)

Wt/Age is better both in cases of recent death (t= 0.64, 31 df, p= 0.25, n.s.) and especially with all deaths since 1950 (t= 1.66, 50df, p. almost 0.05).

Wt/Height is better both in cases of recent infant mortality and in mortality since 1950; the former is not statistically significant (t= 1.54, 56df, p<0.1), but the latter is (t= 2.05, 87df, p<0.025)

Table 8.5.2: Morbidity Levels in Surviving Children of Women with Infant Deaths under ten year olds, clayveld sub-sample only

	n	morbidity		diarrhoea		ENT		Sore eyes	
	child-weeks	n	%	n	%	n	%	n	%
1980-87	55	24	43.6	13	23.6	6	10.9	5	9.1
1950-79	292	110	37.7	31	10.6	31	10.6	10	4.3
No death	416	178	42.8	51	12.3	77	18.5	24	5.8

Notes to Table 8.5.2:
For data categories see above; note that death 1950-79 is separated from 1980-7 in this table, as sample sizes are large enough to take separate analysis.

Diarrhoea is more common in children in kitchens managed by women who have experienced infant deaths since 1980 than other categories (pooled): χ^2 6.95, 1df, p<0.01.

Ear, nose and throat infections (ENT) are less common in households that have experienced a death 1950-87 (1950-79 and 1986-7 combined): χ^2 9.16, 1df, p<0.01

Table 8.5.3 Response to Morbidity with Surviving Children of Women who have experienced infant deaths Under ten year olds, clayveld sub-sample

	n morb	no treat. n	no treat. %	home remedy n	home remedy %	purch med n	purch med %	oral re-hyd n	oral re-hyd %	VHW n	VHW %	clinic n	clinic %	hosp. n	hosp. %	church n	church %
1980-87	24	12	50	4	17	1	4	0	0	0	0	2	8	0	0	5	21
1950-79	110	37	34	17	15	6	5	5	16	12	11	20	18	5	5	8	7
No death	178	70	39	26	15	38	21	7	14	9	5	38	21	1	1	10	6

Notes to Table 8.5.3:
Definitions as above.

Recent deaths have been more common in Apostolic households (see Table 8.4.9), and this is the reason for higher church cures (sample too small for χ^2). Where there has been a recent death there is lower clinic, hospital and VHW attendance and ORS use. To build sufficient sample size the latter four western health treatments are pooled and contrasted recent deaths against 1950-79 deaths and no-deaths pooled. The result is highly significant (χ^2 6.57, $p<0.02$)

Higher no-treatment levels were observed in children being looked after by women who had recently experienced an infant death, but this was non-significant

Greater purchasing of medicines in the 'no deaths' category was highly statistically significant: χ^2 16.1, 1df, $p<0.001$.

The higher anthropometric status of children in domestic units experiencing a sibling death (Table 8.5.1), may reflect either inherent differences in underlying nutrition in these domestic units, or possibly actually be a <u>result</u> of that mortality experience. If it is the former, it shows that whatever factors are associated with causing infant deaths they are highly unlikely to also be those causing low anthropometric status in sibling children aged two to ten years. (It is unknown to what extent sibling anthropometric status is correlated in this population, and whether infants or children who die show similar or different anthropomtetric status to their siblings.) However, there is some evidence to suggest that the better anthropometric status of survivors is actually the result of mortality.

It was found in this sample that both infant and child mortality were greatly reduced by longer preceding birth interval (Chapter Seven, Section 7.3). Since three, four and five plus year intervals have progressively more favourable effects on mortality levels, it was concluded that sibling competition was probably playing a role, in addition to any direct physiological effects of pregnancy and birth. The higher anthropometric status of surviving children in cases of sibling death, may therefore reflect the same phenomenon of sibling competition and the resulting improvements in survivors resulting from sibling mortality.

Tables 8.5.2 and 8.5.3 suggest that there may be morbidity-vulnerability factors expressed in surviving under ten year old siblings that are associated with infant deaths. In particular, higher diarrhoea was observed in these domestic units. Why ear, nose and throat infections are actually lower in children whose siblings died remains open to speculation, and it may not have an important bearing on mortality. High levels of ENT might possibly explain much of the higher purchasing of medicines in this no-death category (along with the presence of the single woman who purchased medicines 13 times). It is possible that purchasing of medicines reduces vulnerability, but it should be noted that in clayveld such purchase is associated with wealth (Table 8.3.12), and education (Table 8.3.16) which seem to have independent effects on mortality (Table 8.4.8). It does appear that use of western medical care is rarer with siblings where a recent infant death has been experienced. If the same reluctance to use western medical treatment existed at the time of the infant death, then this would strongly point to the importance of health service usage as a mortality determinant. This would then combine with what appears to be greater vulnerability to diarrhoea in members of this domestic unit, diarrhoea being the main 'cause' of mortality in this area (Chapter Seven, Section 7.2.1).

8.6 Discussion of the Impact of Socio-Economic Differentiation on Child Welfare

Introduction

The empirical material presented in this chapter provides wide ranging data for the investigation of the interactions of socio-economic variables with child welfare. However, the sample is small, and the variables themselves interactive, even though cross-tabulation indicates that they are approximately evenly distributed against each other (Table 8.0.1). Although efforts are made to control for these interactions, sampling effects may mask or distort the results. Furthermore, these results should not be extrapolated to other rural areas of Zimbabwe, since there are marked regional variations in social and production systems. My results do little more than establish the situation in one area and explore some of the reasons for this; and, if anything, they should be seen as providing something of an agenda for future research on differentiation and welfare in Zimbabwe.

Economic Differentiation: Birthweight and Nutrition

Contrary to expectations, seasonal and inter-annual variations in nutrition tend to be rather similiar in the different wealth categories. Birthweights in the sandveld/boundary zone were lower in the wet season than the dry season in both the wealthy and poor sub-samples; and lower in the dry season in both the wealthy and poor sub-samples in clayveld (Table 8.1.4). Although data are limited, inter-annual variation in birthweight suggests that both the wealthy and poor are equally vulnerable to the effects of drought and excessive rainfall in the respective ecological zones (Table 8.1.5). Data on the seasonal changes in weight velocity of children aged two to ten, are only sufficient to examine the effect of wealth differentials in clayveld. Despite some ambiguity, all wealth categories appeared to show similar reductions in weight gain velocity during the dry season in the clayveld, followed by increases during the rains (Table 8.2.4). Similarly the extent of clayveld decline in weight-for-age status during prolonged drought was equal in all wealth categories (Table 8.2.5); despite the fact that the drought apparently reduced cereal intake only by the poor on clayveld (Chapter Four, Table 4.2.2.4). However, it is significant that the poor started on a lower nutritional plane than did the wealthy, so that the declines amongst the poorer children may have been the result of greater stress, and had greater functional significance.

This study is one of the first investigations in Africa into economic differentials of birthweight and child growth vulnerability to seasonal and inter-annual stress, and does not confirm the oft-cited - but as yet unproven (see Part One this Chapter) - notion that the poor are more vulnerable to these stresses. The lack of significant differences between the relatively wealthy and poor is notable given the contrasts in food procurement and consumption by wealth (Chapter Four). Further, it cannot be attributed to similar vulnerabilities to morbidity by the wealthy and poor, since this itself shows wealth differentials, notably in diarrhoea which is highly seasonal (see Table 8.3.1). Lack of marked differential vulnerability is therefore probably a reflection of the way lineage organisation of production blunts individual household stress (see introduction), even in the clayveld where such organisation is less developed than in the boundary/sandveld populations (see below).

Although the dynamics of seasonal and inter-annual nutritional vulnerability are similar between households of different wealth status, there are marked differentials in nutritional plane between the wealth categories. However, wealth has apparently different effects in the populations of the two zones. In the clayveld zone, the wealthy women, who are larger (Table 8.1.3), have children with higher birthweights (Table 8.1.2), and higher weight-for-age status of two to ten year olds (Table 8.2.1).* In contrast in the sandveld and boundary populations birthweight is actually lower among the wealthy (Table 8.1.2), and the anthropometric status of children aged two in ten in wealthy households is also lower than among children in poor households (Table 8.2.1).

Part of the explanation for this difference in child nutritional status differentials between ecological zones was revealed by analysis of children <u>within</u> households with different lineage relationships to the household head. This was hypothesised to affect welfare provisioning in cases where there was a high degree of lineage orientation, rather than an egalitarian household-centred outlook. Only in the boundary sample were children

* Although many wealthy households have access to borehole water in this ecological zone, access to borehole water did not seem to have a substantial affect on child anthropometric status, Table 6.3.3.2

outside of the immediate patrilineal framework (eg. sister's children, illegitimate children of daughters, etc.) significantly smaller for their age than those with lineage relations deemed more culturally 'appropriate' (Table 8.2.3). It was the presence of many more of these 'outsider' children in wealthy households that was bringing down the average status of the wealthy household children; in fact there was no difference found between patrilineally descended children in the rich and poor households. In clayveld, in contrast, there was no difference between 'outsider' and patrilineally descended children. In both categories of children on clayveld, those in richer households were substantially larger for their age (Table 8.2.3).

The fact that wealthy women and children are privileged in clayveld, whilst the poor are better (or equally as well/badly off) in sandveld and boundary zones, can be related to the differences in the organisation of production (Chapter Four). Though there are as substantial differences in asset ownership between the sandveld/boundary wealthy and poor as there are in clayveld (Table 4.1.1.1), there was actually no grain production differential in this zone in the years 1984-7 (Table 4.2.1.1). (In fact the poor slightly out-produced the wealthy per capita!). Although grain production is but one facet of livelihood, this result well illustrates how the highly developed, and economically egalitarian, patrilineal organisation of production in this population minimises household level differentiation. In contrast, the clayveld households, though still embedded in inter-household clusters of economic cooperation, have a greater degree of household independence. This lineage organisation in the boundary population protects the welfare of poorer households, but exposes children who do not fit in to this system to structural inequalities, leading to overall nutritional differentials. In clayveld, in contrast, children in wealthier households reap sufficient 'consumption' and other benefits from higher production to elevate nutritional status.

The energy-balance component of nutritional status of children ultimately reflects a complex trade-off between the benefits of high production/ consumption and the costs in their own (and their mothers') energy and time to produce that extra income (see introduction, this chapter). The lower nutritional status of children in wealthy households in the sandveld and the boundary populations is thus a product of the costs of being wealthy, (for example, investment in stock that are actually used almost equally by the household heads' political dependents), not being out-weighed by the benefits of consumption privilege. These costs have to be considered alongside the benefits, because it is true that there are indeed some consumption benefits for the wealthy in the boundary population. For example, th dietary study showed that the wealthy in the boundary sample had a better diet than the poor, as was the case in clayveld (Chapter Four, Section 4.3). It can be added, though, that the consumption differentials are remarkably small, considering the wealth differences.

Explaining the opposite relationship between wealth category and birthweight in the two sub-samples (Table 8.1.2) is slightly less straightforward, than that of child nutritional status. Wealthy women in both samples are obliged to work harder in production than are poor women in this zone, in fact the difference between work levels of the wealthy and poor are greater, if anything, in clayveld than in the sandveld/boundary zones. However, in contrast to the sandveld/boundary population, birthweight is actually higher amongst wealthy women in clayveld. The key factor here may be the consumption benefits with wealth realised only in the clayveld sample, due to the more independent nature of production there. Wealthy women in clayveld are heavier than poorer women in this zone (Table 8.1.3). Unfortunately, comparative weight data for sandveld/boundary women are not available.

The importance of lineage and domestic social organisation in determining child nutritional status at the so-called household level is also illustrated by the effect of the gender of the household-head. In both populations higher child nutritional status was found in households where the male household head is absent, or where the household is headed by a widow (Table 8.2.2). This might reflect the way in which male absence frees a woman of much labour and allowed her to direct expenditure and attention more towards the children (F. Shumba, pers. comm., 1989); but no attempt to analyse available data to assess this particular hypothesis has been undertaken.

In short, the relations between economic differentiation and nutritional status can not be understood out of the context of analysis of inter and intra-household organisation. I now address whether these small nutritional differentials, and their opposite directions, are reflected in differences in mortality. In fact it seems that in this particular population, and at this time, mortality differentials may reflect morbidity, and response to morbidity, as much as nutritional factors; this point is now taken up in the next section.

Economic Differentiation: Morbidity and Mortality

A strong relationship exists between economic differentiation and infant mortality rate (Table 8.4.1), and possibly also child mortality (Table 8.4.4). Marked differences in infant mortality with wealth are found in both the sandveld/boundary and clayveld populations (Tables 8.4.2 and 8.4.3), despite the fact that wealth differentials in birthweight and nutrition were in opposite directions in these ecological zones. Since strong relationships between wealth and mortality have been shown in several rural African studies in recent years (see introduction, this chapter), the result is not unexpected. Since in this study data on nutritional status, morbidity, and response to morbidity are available alongside that for mortality, it is possible to seek the causal factors involved.[26] Nutritional status does not follow an identical relation with wealth to that found for mortality. Only in clayveld do the children in wealthy households have higher nutritional status and lower mortality: in the sandveld/boundary population nutritional status remains similar or gets worse with increasing wealth, whilst mortality in this sub-population improves with wealth. Therefore this section will seek the determinants of mortality differentials in contrasts in the levels of morbidity, and in maternal response to that morbidity. But first it is useful to address apparent historical reductions in the closeness of the relationship between wealth and mortality, which may be the result both of an artifact produced by economic mobility as well as changes in the social relations of production since Independence.[27] Since it is impossible to clarify the historical data, the focus now shifts to mortality differentials since Independence (1980) and the morbidity levels assessed in the prospective study of 1986-8.

Economic differentiation appears to affect morbidity differently in clayveld and boundary samples. In the clayveld sample, the children in the wealthiest households show lower morbidity overall. In fact this is almost entirely a function of lower diarrhoea incidence/prevalence (Table 8.3.2). As diarrhoea is the most common 'cause' of death (Chapter Seven, Section 7.2.1) this may be responsible for much of the mortality differential in this population. Even the magnitude of the difference in diarrhoeal morbidity (four fold) is comparable with the extent of the mortality differential. However, in apparent contrast, the boundary sample showed no difference in overall diarrhoeal morbidity between children in relatively rich and poor households (Table 8.3.1); indeed children in richer 'kitchens' actually had marginally higher diarrhoeal morbidity than those in the poorer homes. Closer examination of this data revealed that, in the same way as for anthropometric status (Table 8.3.3), 'outsider children' experienced virtually twice the morbidity of others. 'Insider' children compared across households of different wealth category show results similar to those found on clayveld: wealthier children experience lower morbidity.

Diarrhoeal morbidity determinants include sanitation (Chapter Six, Section 6.3) and nutrition (Chapter Six, Section 6.4). Anthropometric status is apparently associated with morbidity differentials at the individual child level of analysis, but, at a population level, shows neither sufficiently clear association with wealth nor a sufficiently low level overall, to explain such large differences. Sanitation, as measured by the quality and quantity of water used, and the ownership of a latrine, is closely correlated to wealth in the clayveld sample, but none of these hygiene factors can explain why the wealthy experience less diarrhoea, because none was actually associated with lower diarrhoeal morbidity when wealth was controlled for. Though frequency of the sweeping of the yard appeared associated with lower diarrhoeal morbidity - at least in poorer households - (Chapter Six, Section 6.4), wealthier households were not more hygienic in this regard. But it remains possible that other 'sanitation' factors may be responsible for lower morbidity amongst the wealthy. Soap use, rather than simply water, can effect a dramatic reduction in infection (Khan, 1982, see also Chapter Six, Section 6.1.4). Though soap is not used for washing after defaecation or before eating in this society, except in unusual circumstances, there may nevertheless be a general effect of soap on cleanliness and transmission in these households which is responsible for the differences in levels of diarrhoea.[26]

It is difficult to distinguish straightforward sanitation factors and maternal education/knowledge factors (see below), from economic variables; (eg. El Samani *et al.*, 1988 on Sudan; and Freij and Wall, 1979 on Ethiopia). A possible factor is the amount of fuel wood and time women have available for cooking weaning and child foods, since the storage of these foods between cooking may be a major factor in child diarrhoea (see Chapter Six, Section 6.1.4). It is plausible that wealthy women would have more time for these tasks, except in those households where their wealth is the direct result of more intensive agricultural labour. Some dimensions of privilege would be expected to be associated with higher diarrhoeal morbidity rather than lower. For example, *Campylobacter jejuni*, important in the aetiology in wet season diarrhoea in Zimbabwe, is associated with domestic animals and unpasteurised milk (Chapter Six, Section 6.1.4 and Chapter Six, footnote 6). Milk is consumed in greater amounts by the people in wealthier households (Chapter Four, Section 4.3.2), who own most of the livestock (Chapter Four, Section 4.1). Ultimately, therefore, the lower diarrhoeal morbidity amongst the wealthy presumably reflects the balance between a complex and still uncertain range of factors actually responsible for determining the frequency of diarrhoea with different pathogens.

Household differentials in nutritional status and levels of morbidity play a role in mortality differentials, but this could be more important in clayveld than the boundary zone populations. I now turn to <u>response</u> to morbidity as a possible explanation for mortality differentials.

Marked differentials in treatment (response to morbidity) were found between wealth categories, but the differences were not the same in the different ecological zones. In the clayveld zone, richer households more frequently purchased medicines for their children than did the poor (Table 8.3.12), but this was not the case in the boundary population (Table 8.3.11). Unlike the situation in western Nigeria where anti-malarial purchase makes a significant contribution to morbidity prevention and treatment (Orubuloye and Caldwell, 1975), most of these purchases are of patent medicines is of things like cough mixtures and headache tablets.[29] These treatments might ease physiological stress (suffering), but probably do not have a tremendous potential for reducing mortality.[30]

Presumably the use of western health services has a greater significance for child survival than does the use of purchased medicine. The results for the boundary population indicate that the relatively wealthy households make around twice the use of such services per morbid period than do the poorer (Table 8.3.11). This would suggest that use of such services is an important cause of greater child survival in this sub-population. However, the results from the clayveld sample indicate that there are small differences in treatment with wealth differentials; and, indeed, the highest use of western medical care is actually among the poorest households. Thus it would appear that parental treatment differentials by wealth are not responsible for clayveld mortality variation, even if they are for the boundary population. However, the average severity of morbidity may not be equal amongst the relatively rich and poor on clayveld; indeed this is unlikely given that there certainly are differences in the levels of morbidity (see above). Furthermore, richer women may receive better attention when they attend and may thus achieve better child health with fewer visits.[31]

One aspect of health care use that may have an important bearing on differential mortality is that of infant and child vaccination. Unfortunately, this was not investigated in this study.

The general effect of wealth on the use of western health services in Africa remains a topic wide open for research.[32]

I now proceed from the discussion of household-level wealth and morbidity differentials to consideration of domestic organisation. It was noted above that the children had better nutritional status in households where the de facto 'household head' was a woman. This does not appear to be a cause or consequence of lower morbidity in such children (Table 8.3.4). Overall morbidity in female headed-households is similar to that of the male-headed; significantly diarrhoeal morbidity may actually be higher in female-headed households, but sore eyes is probably less common. Children in female-headed households receive 'no treatment' less frequently, and are given much more recourse to western health services, than are children in male-headed households. Treatments of morbidity may therefore be responsible for the differential observed in nutritional status (Table 8.3.14). General care, and food consumption differences, presumably also contribute significantly to their better nutritional status.

Boundary sample children living in households where they had no direct patrilineal relationship to the household head were smaller for their age (Table 8.2.3), and experienced higher morbidity (Table 8.3.3). It was therefore hypothesised that these children might receive less western medical care. However, it was actually found that 'outsider' children received much more village health worker and clinic treatment than 'normal' family members, though much less medicine was purchased for them than for other children (Table 8.3.13). Household financial resources are less often allocated toward these 'outsider' children, but the free (if time consuming) clinic and village health worker services are more often used.[33]

Family size has been used in some African studies as an explanation for welfare differentials between children in poor and wealthy households (see introduction, this chapter). Most African studies find that households are larger for wealthier than poorer units (cf. Chapter Four, 4.1). Although large family size is said to be linked to higher morbidity in the literature, African data have yet to be published. This study found that family size had no clear effect on welfare variables, and thus was not an important factor in welfare differention with economic status in this particular population. One obvious explanation for this would be the observation that children actually spend much of their time playing and working with neighbours - and even sometimes sleeping there. Furthermore, 'family size' may not correlate closely with sleeping density and related disease transmission factors.

Maternal Education and Child Welfare

Maternal education correlated strongly with infant mortality rates (Table 8.4.6), and to some extent with child mortality rates (Table 8.4.7). This is therefore another African study (though the first for Southern Africa) demonstrating the salutary effects of maternal education on child survival (Caldwell, 1979, and see introduction, this chapter, for a general review).

Outside of Africa maternal education is sometimes associated with the mother having greater height and weight. This may be related to the level of parental wealth and investment in the mother when she was a child, better food and health care being correlated with education-provision (Chowdhury, 1982). Larger mothers have more surviving children than smaller ones within deprived communities (Martorell, *et al.*, 1981; Mata, 1978:321; contrary to Frisancho *et al.* 1973). However, no such relationship between education, maternal size and birth weight exists in this population.

Educational status did not appear to influence the likelihood of giving birth in a clinic or hospital (Table 8.1.6) which has been suggested by other studies.[34] There was, however, rather fewer such births recorded by illiterate mothers, though this may simply have reflected that illiterate women more frequently lost birth records. Use of antenatal care and assistance with actual delivery has consistently been found to have a considerable impact upon infant mortality (eg. Ebrahim, 1969:103-4), but I have made no investigation of this in the Mazvihwa area, where significant antenatal services are now provided. Exactly how antenatal care improves outcome of birth in rural Africa is not yet known, but in a malarial region of Tanzania birthweight was higher amongst regular attenders at a clinic than other women, possibly because of the administration of malarial prophylaxis and iron tablets to the women (Bantje, 1983:52).

Since birthweight is similar by maternal education (Table 8.1.6) the differences in the infant mortality rate with education (Table 8.4.6) presumably reflect subsequent 'care factors'. Less clear effects of such 'care' seem to persist to be reflected in childhood mortality differentials (Table 8.4.7), though this may simply be a function of inadequate sample size. This would again suggest that greater use by educated women of antenatal care and/or immediate follow up in MCH 'baby clincs', could be an important determinant of infant mortality, in a way that does not affect child mortality.

The effect of maternal education on mortality is much more significant amongst poor households than rich households (Table 8.4.8). Indeed the relationship between maternal education and mortality is not even statistically significant amongst the richer than average households. The data suggests that illiterate women in the poorest groups have an IMR four times that of literate women in the same poor wealth categories and more than six times that of the other woman in this rural community since Independence (1980). However, this shocking result should not be extrapolated without caution, as the sample sizes are very small, and not collected so as to be representative of the area or region. Yet taking the result as it stands it might be the first study to 'demonstrate that poor but educated women with limited access to effective sanitation or medical facilities nevertheless achieve significant reductions in child mortality' (Ware, 1984:197).

It is noteworthy that extremely low levels of education were responsible for mortality differentials in this study. Nearly all of the improvement with education came with only three years of primary schooling, hardly more than basic literacy. Secondary schooling has been found necessary to depress mortality in most studies (Ware, 1984:196). Basic education seems more effective at lowering mortality in Africa: in the western Nigeria data primary schooling was shown to be significant (Orubuloye and Caldwell, 1975:268-9; Caldwell, 1979), and in the Sudan, mothers with four to six years of primary schooling experienced half the infant mortality of illiterate mothers (Farah and Preston, 1982:367-8).

No systematic field work was conducted to identify the causes of educational effect on mortality in Mazvihwa. This is because mothers never reported there to be such an effect, and I was unaware of the comparative literature whilst doing my field work.[35] The link was not discovered until the statistical analysis after the last field trip, so I did not have a chance to follow it up as I did some of the other surprise 'discoveries'. But discussions and observations confirmed that more educated women tended to be viewed with greater respect by their husbands, relatives, and other local women, which is one of the major hypotheses of how maternal education lowers child mortality (Caldwell, 1979).[36] In practise, however, this 'respect' did not always lead to their maintaining a privileged position. This is because threatened menfolk, and jealousy and competition from co-wives, mothers-in-law or the wives of other close patrilineal relatives, could all lead to their being repressed because of their being educated. Likewise other important hypotheses: that education increases knowledge of health and nutrition, and that education improves women's capacity to access state services, both seem unlikely or inplausible given the low levels of education which have significant effects (three years at primary level). What may well be critical is women's sense of their own worth and capabilities, and how this affects their decision-making at critical times.

In clayveld maternal education showed no overall relationship to child anthropometric status (Table 8.2.6). Maternal education seems to have a greater impact on child nutritional status during periods of peak stress (see introduction, this chapter), which is not what best assessed through the kind of data examined in Table 8.2.6. Important effects on mortality via maternal impact on nutritional status might still exist, but simply not be adequately identified by this measure. Sample sizes are inadequate to examine infant nutritional status, as this is necessarily a better indicator of the determinants of infant mortality than are anthropometric assessments of children aged two to ten years.

Maternal education (actually assessed as that of female guardian or mother) was associated with limited differences in morbidity experienced by children. Boundary population child morbidity was actually a little higher among the educated, but in the clayveld sample illiterate mothers experienced higher morbidity (Tables 8.3.5 and 8.3.6). Different components of morbidity showed little difference between educational categories, except for diarrhoea. Higher maternal education was associated with higher levels of diarrhoea in the boundary population, but slightly lower diarrhoeal morbidity than the less educated in clayveld. There is no obvious explanation for this difference, though it may reflect in part the fact that outsider children are concentrated in these more educated households in the boundary population.

Maternal response to/treatment of morbidity showed minimal differences with education in both populations (Tables 8.3.15 and Table 8.3.16). Educated women purchase medicines more frequently, and make only slightly greater use of western medical treatment. The differences in health care usage appear too minor to themselves be the cause of the mortality differentials. There is no data, however, on the effectiveness of treatment received by women of different education.)[37]

Maternal Religion and Child Welfare

There is some evidence to suggest that maternal religion affects infant mortality in the 1980-6 period, but there was no marked effect observed in data from 1950-79 for infant or child mortality (Tables 8.1.8 and 8.1.9). One of the indigenous church types 'Apostolic' has higher infant mortality than the other maternal religion allegiances, but the other indigenous church ('Zionist') may actually experience lower mortality.

Local people (especially those not members of these churches), readily articulate that there is higher mortality amongst Apostolics and attribute it to their refusal to use western health care facilities.[38] In this particular sample it is only Apostolics and not Zionists who avoid clinical medicine and use church cure treatments (Table 8.2.14). Table 8.4.9 suggests that the declines in IMR achieved since 1980 are in those religious categories ('mission' and 'traditionalist') who have most enthusiatically accepted the increased provision of western medical care. This could be interpreted as confirming the importance of health care provision in the improving status of this population (see Chapter Nine). Although it is tempting to conclude that it is these treatment differentials that are of key importance it should also be noted that it was found that Apostolic children show much higher diarrhoeal morbidity (Table 8.3.8), diarrhoea being the most important 'cause' of child death (Chapter Seven, Section 7.2.1). It is not known why this was the case and it seems unlikely to have been caused by religious affiliation at all. Three Apostolic families, patrilineally related and living adjacently, are responsible for both the mortality and morbidity effects cited here. Familial effects could thus be responsible. Religious affiliation does not affect anthropometric status in this sample population (Table 8.2.7).

Mission church adherents and 'traditionalists' show considerable morbidity differences in the boundary population, but not in clayveld. Though they experience higher morbidity with diarrhoeas (Table 8.3.7), the followers of the mission churches respond to morbidity with more purchased medicines and western health care service use (Table 8.3.17). However, these differences are not reflected in mortality (Tables 8.4.9 and 8.4.10).

Can anything be learnt from studying households with infant deaths?
Most infant deaths have been in the poorer households, amongst illiterate women, especially those who are adherents of the Apostolic faith, who do not use western health care services.[39] Relationships have been shown between wealth, education and religion, and levels of nutrition, morbidity and treatment, but the effects have not been entirely straightforward. This section examines the association between mortality differentials and possible causal factors by comparing children in those clayveld households that had experienced mortality, with those that had not.[40]

Interestingly, anthropometric status was consistently better in households where there had been a death, though the statistical significance of the result was generally weak (Table 8.5.1). This result is contrary to those found elsewhere (Jordan: Tekce and Shorter, 1984:267-71; Malawi: Kurth, 1989:252); but is supported by results from a nearby area of Zimbabwe (Dahlin and Dahlin, 1983). In general, within this particular population, and during the period under study, anthropometric status was not closely related to the socio-economic variables which correlate with mortality-risk. Studies that have shown marked correlations between low anthropometric status and survival have done so in populations with much lower anthropometric status than than those common in this study (Chapter Seven, Section 7.2.2). Likewise the period of high mortality-risk in this population is below one year old, when most children are at, or above, NCHS standards in Mazvihwa. The subsequent decline in anthropometric status, most marked between the ages of one and two, is not a period of elevated mortality. Mortality beyond this age remains low despite persistently poor anthropometric status, (ie. contrary to the situation in parts of Senegal, Rosetta, 1988c). Though the result of better anthropometric status in children in households where there has been a death suggests otherwise, it may still be the case that the children who died were of poor anthropometric status. Higher anthropometric status in survivors might reflect the results of sibling death, rather than the causes (see discussion in 8.5.6, which draws on analysis of sibling competition in Chapter Seven, Section 7.3). The lack of relationship between anthropometric status and mortality demonstrated in this study cannot be taken as having wider significance outside of its present context.

Morbidity from diarrhoea was more common in the children of the households that had experienced recent mortality (Table 8.5.2), whilst ear, nose and throat morbidity was actually less frequent (Table 8.5.2). Morbidity-determinants of uncertain cause thus continue to be found associated with mortality. Households experiencing a death were less likely to seek treatment in a case of child morbidity, though this result was not statistically significant (Table 8.5.3). Lower use of western health services, less purchasing of medicines, and greater use of church cures in this category reflected in part the presence of Apostolic households, but draws attention once more to treatment factors as causes of mortality differentials.

8.7 Conclusions to Chapter Eight

Socio-economic differentials in child welfare are marked within the populations under study, and their demonstration throws important light on the nature of welfare determinants in these rural societies. Important differences are shown between the form and extent of differentiation in the sandveld/boundary and clayveld populations, reflecting, it is argued, contrasts in the nature of the household and lineage organisation of the two production systems. However, analysis and interpretation are constrained by small sample size, incomplete data, and some methodological problems.[41]

One of the most surprising results is that there is very little evidence for differential nutritional dynamics with wealth: both the wealthy and the poor showed the same seasonality and inter-annual variations in each ecological zone in birthweight and child nutritional status. It can be noted that no African study has yet actually demonstrated that the poor are more vulnerable to seasonal and drought year declines in anthropometric status.

The only limited material that exists for rural Africa shows that maternal education, and to a lesser extent wealth and religion have important, but variable, effects on child welfare status. This is the most detailed study to date in rural Africa, as it includes considerations of birthweight, child nutrition, child morbidity, treatment of morbidity and mortality in the same population, analysed in relation to wealth, maternal religion and education, family size, and domestic organisation.

Maternal education has a big effect on infant mortality, but shows no relationship with birthweight or child nutritional status, limited link with morbidity (in opposite directions in the two ecological zones) and a small effect on treatment (with more western medical care for the educated). No data were collected as to whether more educated women make greater use of antenatal and MCH 'baby clinic' care (including vaccination). The causal determinants of the effect of maternal education on infant mortality are thus still largely unknown, but the biggest effects of education were found among the poorest.

Existing research on the relationship between wealth and child welfare - and an understanding of African social and production systems - has indicated that simple effects should not be expected. In fact there were opposite relationships between wealth and birthweight, child nutrition and morbidity in the populations of the two ecological zones, largely reflecting contrasts in the nature of intra- and inter-household organisation; the relationships with nutrition, and especially morbidity, being actually also the result of intra-household factors, an approach never previously taken. Mortality relationships, however, are marked and in similar directions in the populations of both ecological zones. It is possible that these mortality relationships reflect differences in underlying morbidity in the clayveld zone, but, in the boundary population, mortality differentials could reflect treatment responses.

Mortality differentials with maternal religion indicate that higher mortality is experienced by Apostolics, a religious group who do not use western health care. This group also suffered higher diarrhoeal morbidity, but it is difficult to see how this could be caused by religious affiliation, drawing attention to familial affects.

Most of the investigations reported here thus indicate that vulnerability to disease and treatment response is a more important than nutritional status in causing mortality differentials in this particular population. Indeed this observation is further supported by studies of children in households where there has been a recent death. However, a conclusion that nutritional factors are also not involved, would be unwise given the constraints in the analysis; especially given that poor nutritional status has been shown linked to higher morbidity in this population (Chapter Six, Section 6.4). Unfortunately it has not proven possible to discover the causes of these morbidity differentials, as those sanitation-variables that vary with wealth, are not actually asociated with reduced morbidity (Chapter Six, Section 6.3).

In Chapter Nine examination of historical changes in welfare - especially since Independence (1980) - provide another angle on the interaction between the ecological dynamics of welfare stress and the socio-economic determinants of welfare.

CHAPTER NINE

THE HISTORICAL DYNAMICS OF WELFARE AND EVIDENCE FOR A SURVIVAL REVOLUTION SINCE INDEPENDENCE (1980)

Introduction

This thesis has explored the way which ecological dynamics affects human welfare in an African agro-pastoral population. This has been done through an examination of contrasting seasonality and inter-annual variation in adjacent populations living on different soil types. Analysis at community level showed that between ecological zones there were opposite patterns in seasonality and inter-annual variation in most dimensions of food production and consumption (Chapter Four), birthweight and nutritional status (Chapter Five), morbidity (Chapter Six), and in mortality - but not fertility - (Chapter Seven). An exploration of socio-economic differentials (Chapter Eight) indicated that there were marked differences in nutritional, morbidity and mortality variables with wealth, domestic/lineage organisation, and maternal education and religion. However, the limited analysis possible (wealth by birthweight and child nutritional status) suggested that there was little effect of differentiation on the seasonal and inter-annual dynamics of welfare variables.

It now remains to enquire into the historical dynamics of child welfare; and this is required for two reasons. The first is that the patterns of settlement and the production systems utilised in response to the underlying rainfall variability and ecological dynamics of the two zones (Chapter Three) have changed markedly during the last century (Appendix Two). Therefore consideration of mid-1980s environment-welfare relationships conveys an inaccurate 'environmentally-determinist' scenario. Secondly, there have been marked historical changes in those welfare variables for which long term data are available (principally mortality and fertility). These changes have apparently occurred independently of ecological determinants and so also need to be addressed if this thesis is to produce a balanced - or at least contextualised - argument for the impact of ecological dynamics on human welfare. As the time of study (mid-1980s) fell just following a period in which major advances in welfare had been reported (notably a halving of Infant Mortality Rate), insights from a combination of cross-sectional analysis of welfare differentials and retrospective questioning, can be used to tease out possible determinants of this "survival revolution". It is meeting this latter objective that dominates this short chapter, since it is a question that can be squarely faced with empirical data.

The chapter is divided into three sections. The first, Section 9.1, addresses evidence for changes in mortality (and the limited material on nutrition and health), particularly the nature and causes of the "survival revolution" achieved since Independence in 1980. Section 9.2 then examines reductions in fertility in relation to socio-economic changes and contraceptive extension. Finally 9.3 briefly explores likely changes in the seasonal and inter-annual dynamics of welfare (viz. Chapters Five, Six and Seven) consequent on changing human ecological relationships traced out in Chapter Three and Appendix Two.

9.1 Historical Changes in Child Welfare, and Evidence for a Recent Survival Revolution in Zimbabwe

Introduction

Data will be presented later in this section that suggest there have been broad changes in child mortality in Zimbabwe this century, with two threshold periods, the first around 1950, which was then followed by a period of remarkable stability until the second which occurred at Independence (1980). Although there will be brief examination of mortality changes in this earlier time period, and of changes in nutritional status, I shall concentrate on the "survival revolution" that has occurred with Independence.

Since Independence (1980), which in Zimbabwe marked a significant turning point in socio-political organisation and morale, the new government has greatly improved rural education and health services, as part of a programme to modernise rural people, bring them into the mainstream of socio-political life, and to improve their general wellbeing. Part of this programme has also been to increase rural production and market integration into the national economy; this latter objective is centred around the 'modernisation' policies of extension, rural credit and land-use planning. In the few rural areas with high agricultural potential, these policies and farmers own organisation (Bratton, 1986), have enabled existing rural elites and middle farmers to achieve considerable production and sale advances (Callear, 1984; Mumbengegwi, 1986:215-8; Cliffe, 1988:313; Weiner, 1988:68-9, 73-4, 83; Drinkwater, 1989a). In the low potential (basically drier) areas the lack of suitability of the recommendations to the actual social and ecological conditions has meant little agricultural success, even for elites, especially given the fact that the 1980s has mainly experienced low rainfall. In these low potential regions, which include the Mazvihwa study site, economic advance since independence has centred principally around growing remittance incomes for those few with access to elite urban employment, with the overall proportion of the population in urban employment declining at national level (cf. Stoneman, 1988:58). In addition, there has also been an increasing monetization of exchange and working relationships within the rural areas, that has occurred in the absence of economic growth.[1]

It must be noted that despite the optimism that accompanied the exceptional economic growth in the year of Independence (1980), since that year economic growth at 1.5%/annum has been unable to keep up with population growth (3%/annum), so that per capita incomes are falling (Stoneman, 1988:58). Despite initial benefits to poor population sectors due to minimum wage legislation, falling real wages at the lower end of the scale and the removal of food subsidies has meant considerable economic hardship, especially for those poor not self-sufficient in food production (Chanetsa, 1985; Sanders and Davies, 1988:196-8). These economic problems are hardly surprising, given that Zimbabwe has been caught in the African economic crisis and subjected to IMF and World Bank 'adjustment' and 'recovery' policies (Green and Kadhani, 1986; Davies and Moyo, 1988; Kalyati, 1989; Sanders and Davies, 1988).

Although some resettlement of peasants on former 'commercial farming' land of white settlers is occurring in Zimbabwe, it has had a negligible effect on land-use and population in the existing communal lands (Moyo, 1986; Weiner, 1988:79-82; Cliffe, 1988:314-7; Sanders and Davies, 1988:197-8), indeed it is proceeding slower than population growth in these Communal Areas. In the Mazvihwa area itself, as in many of the most crowded Communal Areas, spontaneous migration to less crowded Communal Lands in the north (Gokwe and environs) has been far more significant numerically, though it has also had minimal effects on resource pressure within Mazvihwa.

This situation of changing service provision and socio-political transformation (which will be detailed in later discussion), but relatively little economic change, thus provides an interesting test of Caldwell's (1986) argument that advances in rural welfare can be achieved without general economic growth. Before proceeding further it must be noted that the discussion and conclusion of this section are necessarily limited by the fact that I am reporting a small case study of a rather marginal population in a country that is regionally differentiated ecologically, socio-economically and politically. Nonetheless, the question does seem worth asking, and this section now examines the ideas of Caldwell and others on "survival revolutions", and sets them within the context of the African savannah literature (particularly work on the effects of curative services), so as frame the analysis and discussion of the Mazvihwa data.

Survival revolutions: comparative data

The critical importance of social change

Two recent major studies to try to use socio-economic variables to account for international differences in mortality rates in 'third world' countries have drawn attention to a number of rather unconventional variables, with the general economic situation playing rather little role. Flegg (1982:523-4) draws attention to the degree of inequality in income, the educational attainment of women, and the number of doctors per unit population (in that order), as the most significantly correlated with child mortality. Caldwell's essay (1986) begins by attacking the view that the principal determinants of mortality are simple economic wealth factors, and also the idea that medical technology alone can bring health. He shows that country rank by per capita income is fairly unrelated to rank by mortality (1986:175). Significant disparities in mortality rates by wealth occur with national religion; in particular Islamic countries have much poorer rank by mortality than by economic indicators, and this is not purely an effect of recent increases in income due to oil exploitation. Caldwell argues that this relates to the position of women (1986:174-7). Caldwell then reports that female education in 1960 has an uncanny relationship with infant mortality in 1982, much more so than does male education (1986:177-9). There is some effect of the level of health services on mortality, especially the density of doctors - and possibly family planning - but this is not as strong as female education. Caldwell is not espousing a naive view about the importance of 'modern outlook' or of female educational status somehow having a determinist effect divorced of social and political context. For example, he shows that arguments that belief in germ theory are behind modern mortality declines are basically fallacious (1986:206-7).

Moving from a general discussion of international mortality differentials and their correlates, Caldwell describes the 'breakthroughs' achieved by three states (Costa Rica, Kerala and Sri Lanka) that have made exceptional improvements in life expectancy not through any overall economic growth, but through 'economic and social will' (1986:172). During their "survival revolution" all of these places were characterised by: female autonomy, an open political system, civilian society, no rigid class structure, a history of egalitarianism, radicalism and 'national consensus arising from political contest with marked elements of popularism' (1986:182). Achievements were secured in part through advances in the position of the poor, including a nutritional 'floor' for the destitute, but especially important was a great expansion in health services. However, Caldwell shows that expanded health services only worked because there was a public demand for these measures that was strong enough to ensure that they really reached the people, and met their actual needs (1986:201-4). It was female autonomy that enabled this to occur, where female autonomy is not the same as 'respect' or 'status', but involves the genuine desire and ability of women to take an equal place in society (1986:202). In this sense female education becomes something of a proxy for female autonomy, and hence correlates closely with mortality at the national level. Ideas about the central importance of women's autonomy and attitudes can be linked to the argument of Mosley (1983; 1984:3-4, 6-7) that health service provision is only as effective as community (especially maternal) acceptance (or demand) enables it to be (see also Dugdale, 1980:383; Chen, 1986:1263), and the view of Caldwell that a reduction in 'fatalism' (1979) and 'identification' with the 'modern' social order are important (1986).[2] The material presented in Chapter Eight on mortality differentials certainly reinforces the view that maternal attitudes are of central importance, since large differences in infant mortality are associated with minor differences in female education.

Applications to Post-Independence Zimbabwe

Caldwell's description of revolutionary populism as the special feature pertaining to his three major achievers of reduced mortality, would be applied by many observers to Zimbabwe, and is certainly how the government would like to see itself. However, Caldwell has argued that the mobilisation of these ideals in the countries in question was achieved not through a vanguard leadership, but through the expression of popular consciousness. Elements of the struggle for independence in Zimbabwe were certainly populist, achieving wide involvement of rural people (Ranger, 1985). However, Ibbo Mandaza has eloquently addressed the mythologisation of the participative involvement and revolutionary content of the political and military independence movement (Mandaza, 1986:4-7).[3] Such work demonstrates clearly that Zimbabwe has still to achieve a popular political process and to develop political mechanisms to curb the power of the growing economic elite and foreign interests (cf. the essays in Mandaza (Ed), 1986). In the language of Caldwell, the success of Zimbabwe might therefore lie part-way between 'political and social will' (Kerala, Sri Lanka and Costa Rica) and 'political will alone' - that is without as much popular participation - (cf. the achievements of China and Vietnam).

Two post-Independence social programmes in Zimbabwe, coordinated by the Ministry of Community Development and Women's Affairs, deserve particular mention as possible contributers to a changing social world for women, thus facilitating mortality fall. The first springs in part from the role that women played in the independence struggle, and is the way in which the government has passed legislation that improves women's rights in certain ways tackling some of the severe constraints of customary and colonial law (May, 1983; Kazembe, 1986; Zanu, 1985:251-3; Batezat *et al.* 1988:156-60). Women have also been encouraged to form political committees, and to engage in political affairs, although the absolute numbers involved are still small (Kazembe, 1986:400-1; Kachingwe, 1986:32). Furthermore, some development programmes have been aimed at rural women, especially a series of 'income generating projects' (Zanu, 1985:247-50), though these have been largely ill-advised and had little impact (cf. Muchena, 1985; Batezat *et al.*, 1988:162-4). Secondly, part of the platform of universal, non-fee-paying primary schooling, and the several-fold expansion in secondary education has been greater female education and less inequality in educational achievement between the sexes.[4] The large adult literacy campaigns (Zanu, 1985:254), not unproblematic as they have been,[5] have been mainly utilised by women (Batezgat *et al.* 1988:162); indeed men have often been reluctant to participate in them alongside women (Grainger, 1987:55). Female literacy in Zimbabwe now stands at 67% (UNICEF, 1988:66).[6] Although these measures must be seen as having had little fundamental effect on women's rights in Zimbabwe, they have certainly raised the level of rural consciousness of gender issues, and have acted as a confidence boost to many rural women.

I return to the effect of improvements in health service provision in Zimbabwe, and the possible improvement of nutritional status, after the discussion of disease environments and the role of curative health services below.

The importance of disease environments

One danger in pursuing a socio-economic analysis, with a focus upon social change, is that the successes in privileged areas can lead to over-optimistic expectations for other regions, and/or assumptions that mortality is high in these areas with low levels of socio-economic development because of this 'under-development', when actually much of the effect is due to the fact that 'unhealthy' environments also tend to have low levels of economic and service development. Disease environments cannot be ignored in Africa where several tropical diseases are so severe that current potentials for socio-economic development will not be able to lead to their suppression as major mortality-factors (Desowitz, 1980). Of particular significance is malaria, virtually uncontrollable in many areas of Africa, and responsible for tremendous infant mortality (Bradley, 1988; Wenlock, 1979a and 1979b;[7] a description of one such area is given by Collis *et al.* (1962).[8] There is some evidence for socio-economic differences in malarial prevalence in Africa, for example, in Lagos where it reflects a combination of mosquito net and anti-malarial use (Rea, 1970:227), but in most rural communities there is very little potential for widespread protection.

The degree of impact of disease-environments will continue to be controversial as it is not possible to separate socio-economic development from disease environment in Africa. For example, Sembaje (1983) found no method to distinguish correlations of wealth with altitude and wealth with mortality in Tanzania. However, an interesting approach has been followed by Farah and Preston (1982), who, by controlling for education and socio-economic variables, showed that there were regional differences in mortality within the Sudan. The Southern region was an area of particularly high mortality by national standards. This may partly be related to service provision: eg. well serviced Khartoum has lower rates than neighbouring rural areas, and the Southern Region has particularly poor medical services. But the authors believe that there is greater malarial exposure in the higher rainfall, and, in many areas, swampy, south, and that this is the major causes of differences in mortality between the children of women of similar socio-economic status in the south versus the north. Farah and Preston also refer to similar differentials reported in Kenya and Tanzania (1982:373-4).[9]
Outside of Africa it has sometimes been possible to tackle disease environment effects with technical measures, and analysis of the results have revealed their previous importance. For example, Gray (1974) produced fascinating results in somewhat controversial work on the impact of malarial control programmes in Sri Lanka. Inter-district mortality differentials prior to 1945 could be almost entirely explained by variations in malarial prevalence. Post-war malarial control contributed 23% to mortality declines, and effectively eliminated regional mortality differences.

Disease environment in Zimbabwe

The area of study (Mazvihwa) lies on the edge of the one of the plateaus that form islands of more healthy, agriculturally productive and higher populated places in the East/Southern African region. Currently much the most developed areas of the region, these plateaus can achieve very low mortality in favourable socio-economic circumstances, as the disease-hazard is relatively low. Therefore the plateau - and its southern edge - contrasts with the Zambezi valley which marks the northern border of Zimbabwe, where malaria is prevalent.[10] Here an Infant Mortality rate of 300 has been estimated by both pre-independence and post-Independence writers (Gilmurray *et al.* 1979:23 and Sanders and Waterston, 1983). These authors have attributed this high mortality to poor health service and general neglect, which is dubious (Thomas *et al.* 1979:234) given that contrasting disease environments are clearly also important. Mortality in the medium and high veld of Zimbabwe can therefore be expected to be much more responsive to socio-economic change and curative health service provision than in the valleys of the Limpopo in the south and Zambezi in the north, and to many other areas in central Africa.

The role of curative and primary health services in reducing mortality in Africa

Studies of the impact of primary health measures including immunization, growth monitoring, ORT extension, contraception and maternal diet supplementation have generally produced positive results (Lovel, 1989), but this research has generally been outside Africa. Work in Africa has been more limited, and contains evidence both for, and against health services being able to make a major contribution to mortality reduction. Some of the more important material is now reviewed.

Several medical teams have published the results of providing exceptional improvements in services on the measured effects on mortality.[11] Dr David Morley's service in rural western Nigeria collected data which led them to believe that nothing else could have such a dramatic effect so quickly (1963:87-8). Prior to the health service provision (1957) the neonatal, IMR and child (1-4) mortality rates were reported as 78, 295 and 277 respectively; but by 1962 these had reduced to 20, 72 and 43 (1963:83). According to a subsequent evaluation comparing Morley's villages with neighbours in 1967, the IMR was 27% lower and the 1-4 year old death rate 61% lower in the villages with the health service, (Cunningham, 1968; though these results have been questioned, Orubuloye and Caldwell, 1975:60). In another West African study during the same period (1965-7 in Senegal), by Cantrelle (1969), the following IMR differentials were reported: in villages with good health services IMR was at 40, in villages with some service it was 117, and in villages without services it stood at 141. More recently (Lamb *et al.* 1984) a highly capitalised health service established in three isolated Gambian villages over eight years, the perinatal mortality was lowered from 109.6 to 45.5, the Infant Mortality Rate from 148.5 to 45.5, and the child (1-4 years) mortality rate from 109.1 to 13.3. Maternal mortality was also reduced: there was no single pregnancy-related death over eight years, when for that population 16 women would be expected to die according to national averages.[12]

In an extremely careful study, Orubuloye and Caldwell (1975) were able to establish without doubt that a long term and effective health service that was in high demand from the populace was able to lower mortality rates significantly. Subsequent presentation of the result together with the effect of maternal education, has thrown it into an even clearer light (1986:204). The provision of health care to illiterate mothers would increase life expectancy by 20%, whilst a 33% increase could be achieved by providing them with education without health services. However, it appears that providing both would increase life-expectancy by 87%, which Caldwell (1986:204) notes is more than simply an additive or multiplicative effect.

The strategy of using curative health technology as a short-cut to health without the elimination of poverty has often been questioned on the basis that it does not tackle the root causes of ill-health, such that the person will therefore be simply re-exposed to infection (eg. Wisner, 1988).[13] Furthermore, there has been a very naive approach to Primary health care that assumes that the mere provision of health personnel and services in rural areas will facilitate participation, and which has often failed to account for local institutional arrangements and political interests which hinder success (Twumasi and Freund, 1986). Okubagzi (1978) reports how twenty years of curative medicine in rural Ethiopia, for example, had no effect on sources of drinking water, latrine use, vaccination status, hygiene knowledge/practice, levels of trachoma and skin infection and weight of children (no data were collected on mortality). Health service provision to settling Turkana in northern Kenya showed minimal effect upon death rates (Brainard, 1986). Only sophisticated and sustained medical treatment can prevent mortality where a significant proportion of the population is moderately or severely malnourished. This level of treatment is extremely rare in rural Africa. For example, the control of measles mortality through immunization in Zaire did most certainly reduce measles mortality in the short-term, but the net gain in survival over a longer period was very small, due to other disease exposure and poor nutritional status (Kasongo Project Team, 1981). Follow-up of discharged diarrhoea patients (aged 3 months to three years) in Bangladesh showed that, during the subsequent year, those with poor anthropometric status had shown significantly higher mortality risk than that seen on average in the area (Roy *et al.*, 1983). Studies like these have been used by by Mosley (1983, 1984) and others to question even whether the UNICEF 'child survival revolution' which is based on low-cost, proven medical technologies directed at the major killer diseases, is appropriate and whether it will work.

Contribution and Changing Patterns of Health Services in Rural Zimbabwe

During the early years of the colony, the first concern of the health service was to treat white settlers. Then:

> 'Two factors forced the administration to provide a rudimentary health service for certain sectors of the indigenous population. First there was the danger of epidemic disease spreading to the white community; and second, profitability depended on maintaining the health of the labour force (particularly in mining). Thus mine and infectious diseases hospitals were established.' (Loewenson and Sanders, 1988:135).[14]

Mission and some government hospitals and clinic services were established in rural areas from the late 1920s, with preventive services starting in 1948 with the establishment of Provincial Medical Services (Gelfand, 1976; Loewenson and Sanders, 1988:135-6). It may well be that the late 1940s, early 1950s marked a watershed in the general availability of health care for Africans, particularly in towns (Bloom, 1985:456,463), but a thorough review has not been made in this regard. This is significant as 1950 appears to be an earlier period of marked mortality change. Despite growing provision to African populations in the later colonial period, enormous health care differentials between races persisted until independence (Gilmurray *et al.* 1979; Agere, 1986).

Starting in the late 1960s, and then through the 1970s, there were attempts to greatly improve the urban, and, to a lesser extent, rural, health services in Zimbabwe. For example, in the Chirumhanzu Communal Area, pulmonary tuberculosis was controlled by better treatment and follow-up, and with the support of health assistants, teachers and clubs, health education and nutrition gardens were possible to back up the baby clinics started in 1965 (Kirsch, 1975:219). Davies (1976:152-3) reports on the efforts in Harare (then Salisbury), whereby 'well-baby' clinics increased in attendance from 60,000 in 1973 to 150,000 in 1974, and large scale vaccination programmes led to a decline in measles, a small decrease in whooping cough and the virtual control of polio, diptheria and neonatal tetanus. It was the influx of 'refugees' into the capital during the late stages of the liberation war that brought large numbers of non-immune children in close proximity that leading to new epidemics of measles in the capital (Axton *et al.* 1979:242; Ross, 1979:267). However, there had been some immunization programmes in the rural areas from the 1960s through the 1970s, even if not fully effective (Pugh, 1978d:99; Thomas *et al.* 1979:233), combined with other advances, such as village health workers (Pugh, 1978a:37), child 'Health Cards' (Pugh, 1978e:123), maternity services (Pugh, 1978e), and health education (Pugh, 1978f). Preventative sanitation programmes were also initiated, including protected wells (Pugh, 1978b) and pit latrines (Pugh, 1978c).

The pre-independence attempts to widen and transform health programmes, provided experience that was used to argue for, and design, the remoulded rural service after independence (Gordon, 1980), in the face of much reactionary opposition (see, for example, Thomas *et al.* 1979); and attempts by powerful (largely white) interests to establish a 'neo-colonial' service maintaining investment in sophisticated curative services for the wealthy (Bloom, 1985:458-63). However, attempts to create a genuine primary health care service under settler rule were doomed, due to combination of inadequate resource allocation from government and political constraints on genuine African participation. Resistance to vaccination programmes by nationalist political parties occurred in the 1960s (Thomas *et al.* 1979:233). The guerrillas, and the populist local forces they unleashed, greatly curbed the activities of many health service institutions in the 1970s (Pugh, 1978g:199; Ross, 1979). However, certain programmes with more creative relationships with local people, and some of those prepared to treat the guerrillas, managed to continue operating throughout the war years.

It is understandable that there has been little empirical research into the effect on welfare and mortality of past rural health service developments in Zimbabwe. Public health measures in Gatooma (Kadoma) townships in Zimbabwe during the UDI years were noted by Mossop (1981:254) to have more than halved infant mortality over only ten years. These measures/changes included health education, improved housing and sanitation, a slight rise in real income, and measles immunization at the end of the period. (There were also improvements in anthropometric status). A less encouraging picture was painted by Stoughton (1975) writing of Bikita (a Communal Area two hundred kilometers to the east of my study area). Through interviewing mothers at the hospital,[15] he established from birth-mortality schedules, that there had been no decline in mortality since 1967. This was despite the fact that 'Medical facilities had improved, transportation is more available, and well baby clinics have become established. Smallpox is almost non-existent; tuberculosis, polio, whooping cough are on the decline . . . I think [the reason why there has been no mortality decline is] the large number of deaths caused by diarrhoea and pneumonia, plus . . . malnutrition'. Stoughton identified a combination of general economic development and preventive medicine and health education as critical.

It should be noted that in Zimbabwe, as in South Africa, there has been a changing pattern of diseases over the years, especially in the urban populations, from those characterised as linked to 'deficiency' to the 'degenerative' type that have historically been associated with privileged western populations; these appear particularly associated with dietary changes (Donaldson, 1971; Gelfand, 1971; Walker, 1972).

By Independence there had been considerable changes in attitudes to illness, and a large scale acceptance of the capacity of western curative treatment to be effective (Kavumbura and Mossop, 1980), in contrast to the earliest years (Thomas *et al.* 1979:233). However, in the rural areas, there is still much easily treated disease that people are reluctant to take to medical services due to distance and a lack of confidence in western treatments, for example as reported in the Chidadomoyo area in Matusadona (Levy *et al.* 1986). Nevertheless there is also evidence for increased notification of certain diseases since Independence (Taylor and Thomas, 1981). **N'angas**, the so-called traditional herbalists, who usually heal with the assistance of 'spirits' (Gelfand, 1964; Reynolds, 1986), remain important in treatment, perhaps especially so in urban areas, where most recent research has been conducted on them (Gelfand *et al.* 1981; M. Hull, pers. comm., 1987). In the Mazvihwa study area **n'angas** appeared to have maintained a role in certain adult treatments, but were of negligible significance in child treatment. A wide diversity of local people continually ascribed this declining utilisation as not due to factors of reducing belief, but to the fact that **n'angas** were commercialising their operations at a time when western health care services had become free.[16]

Post-Independence rural health care initiatives have focused around making health services available to all population sectors, and the development of primary health care, within the general framework established by UNICEF, and reflecting the 'popular' model articulated during the liberation struggle (Bloom, 1985:463-7; Johnson, 1986; Zanu, 1985:189-224; Loewenson and Sanders, 1988:138-9). Between 1980-1 and 1982-3 the overall budget for health care was increased 25%, and, more significantly, the preventative component of the budget has increased more than 300% (Agere, 1986:364). Importantly, the more recent financial pressures on the Ministry have been absorbed by cut backs in curative service expenditure, rather than preventative health (Loewenson and Sanders, 1988:144). By 1984 it was estimated that over 10,000 protected wells and 40,000 Blair toilets had been established (Agere, 1986:372). Despite the emphasis on preventative services, the lack of contribution to decreased morbidity in this sample made by the sanitation improvements being promoted - pit latrines, water supplies - (Chapter Six, Section 6.3), throws doubt upon whether this has contributed much to the survival revolution since Independence.

Curative services have been remarkably improved since Independence. There has been an expansion in rural clinic services, redressing former inbalances in care provision in both Communal and Commercial Farming Areas (Waterston and Sanders, 1984; Edmonstone, 1984; Agere, 1986:364-5); notably through the establishment of Rural Health Centres staffed with State Registered Nurses and Health Assistants (Pugh, 1987:103). Drug usage has been rationalised, and health staff trained in improved prescription (Laing and Ruredzo, 1989).

Services at these clinics, and in hospitals (many of which were formerly racially exclusive), is effectively free for rural people; the fee paying threshold being a salary of Z$150/month (Bloom, 1985:464); this was the equivalent of £60 at time of field research. Prior to Independence only a minority of people in this sample were within a day's walk of a clinic, and the services available were much less than they are today. The nearest hospital to which rural Africans had access required a very long walk and two bus journeys on routes where there were not daily services. (A single bus journey is now sufficient, with five buses a week, passing right through the study area; with part of the bus route tarred since 1988). A journalist, Raath (1985), reporting sources in Harare, recorded that 71% of the Zimbabwean population had medical services within 5km of their home by 1984.

Starting in 1982, Village Health Workers were selected by Village Committees (Vidcos), or District Councils, and given elementary training and a selection of basic drugs, working in exchange for a small stipend (Z$36/month; Zanu, 1985:192-3; Johnson, 1986; Loewenson and Sanders, 1988:141). There were 3,800 Village Health Workers trained by 1984 and 7,000 by early 1987. Despite some problems of support, supervision and community accountability/control, the programme was operating effectively in the mid-late 1980s in most Communal Areas (Loewenson and Sanders, 1988:141; Zanu, 1985:193), though the provision to Commercial Farming Areas fell behind (Edmonstone, 1984:158). The significance of these clinic and village health worker services is indicated by their high frequency of use, the average child in Mazvihwa receiving treatment more than five times a year (cf. Chapter Eight, Section 8.3).[17] This success not withstanding, there are still constraints on real participatory health programmes in rural Zimbabwe (Tumwine, 1989).

An extended programme of immunization (EPI) against the six major childhood infectious diseases has been conducted, and full immunization coverage for children aged 12-23 months increased from 25% in 1982 to 42% in 1984 (UNICEF, 1985:26); and by 1987 the figure was as high as 60-70% in some Provinces (Loewenson and Sanders, 1988:140). However, the programme has been faced with many constraints, leading to some technical failings with the cold chains etc, (cf. Ray and Todd, 1986; Pugh, 1987:104-5). Though UNICEF (1985) referred to the advance against measles as 'slow', and the percentage of children immunized against measles in 1985/6 (53%) was slightly down on that for 1981 (UNICEF, 1988), the achievements have nevertheless been remarkable.[18] The effectiveness of even such incomplete measles immunization on mortality in a scattered rural population can be appreciated when it is considered how vaccination reduces not only the overall number of cases, but the number of co-occurring cases, and therefore the overall mortality rate, including in non-immunized children (Roberts, 1984; Aaby *et al.* 1985). Although there is no real data, there is good reason to assume that ZEPI has improved child survival in Zimbabwe (Sanders and Davies, 1988:201). Nevertheless, immunization has been undertaken within a rather technocratic framework, and although there has been some understanding of its purposes conveyed to rural women, few really understand its nature and the role of the Road to Health Cards (Woelk, *et al.* 1986:71), though nearly all children now have one (cf. Loewenson and Sanders, 1988:140).

The use of Oral Rehydration Therapy (ORT or ORS) has been extended through the Diarrhoeal Disease Control Programme, and most rural people have now heard of it - and nearly all have the equipment necessary to make it (Zoysa *et al.* 1984b). However, people are still not using it very frequently, I found a mean rate of 12% of diarrhoeal episodes treated with ORS (Chapter Eight, Section 8.3). The figures reported in other surveys have been rather lower: UNICEF (1988:19) report contemporary rates of 4-8% per diarrhoeal episode and Zoysa *et al.* (1984b), around 5%.[19] Although acknowledging a lack of data, Sanders and Davies (1988:201) nevertheless argue that ORT extension has improved child survival in Zimbabwe.

Monitoring of weight-for-age status using Road to Health cards has been instituted in most areas, but except during the 1982-4 drought, there has been little systematic use of the weighings to inform response by clinic or mother. Furthermore, it is not at all clear what the health services can actually achieve with such information. For example, Pugh (1987:103), recording that 30% of the children from Binga in the Zambezi Valley fall below the 3rd centile on the weight-for-age chart, bemoans that: 'In other words, our services are reaching the people but we are not able to solve nutritional problems ourselves'.

Attempts have been made to link 'traditional' healers with the 'western' health care services,[20] the former being organised into a professional association 'Zinatha' (Zimbabwe National Traditional Healers Association), though the exact relationships with western health care services and any patient-benefits are still unclear.

Changing Nutritional Status

In Caldwell's (1986) description of successful health revolutions, the establishment of a nutritional 'floor' for the poorest sections of the population was said to be significant. Empirical studies reviewed in Chapter Seven (Section 7.2.2) show that where populations - or population sectors - reach high levels of clinical malnutrition, elevated mortality results. But since there is very little historical longtitudinal nutritional data in Africa, or even Asia, that can be analysed together with changing mortality or morbidity, little quantitative attempt has been made by scholars to document the role of nutrition in health revolutions.

Evidence for Changing Nutitional Status in Zimbabwe

To date I have not been able to locate data on early colonial nutritional status in Zimbabwe. Early colonialists generally reported that 'Shona' were plump and healthy (Selous, 1893:97; De Vaal, 1896:221-2, 284-5), even if adult men were of light build, and medium height (averaging 5ft 4 inches) (Eckersley, 1895:43, 45). Yet these kind of observations are clearly not of a quality that can be used to frame an argument. One promising source of long term data - heights and weights of mine recruits - has not been systematically examined to my knowledge. A doctor involved in examining immigrant labour from Zimbabwe and elsewhere into South Africa observed a decline over several decades in the early colonial era (Dr J.B. Davey in Platt, 1947:391-2), which he related to impoverishment in diet, including as a result of game hunting regulations. Diet was also thought by the Rhodesian Government Nutritionist to be declining in quality at this time due to westernisation (Baker-Jones, 1956:61).[21] Government agricultural regulations and land-use planning were being reported by the Nutrition

Council to be damaging diet and worsening nutritional status. Demarkating arable lands on useless soils due to poor technical capacity, destocking livestock to levels below those required to meet protein requirements, and banning wetland vegetable production, were all cited as harmful by Government reports in the 1940s and 1950s.[22] In the early 1970s households in the Chiwundura area with larger than acceptable cattle holdings and illegally farming natural wetlands were shown to have better nourished children (Theisen and Marasha, 1974:22-3; Theisen, 1976). Therefore Theisen joined the populace in opposition to land use planning and de-stocking on the grounds that it was detrimental to welfare. These suggestions of declining nutritional status during the colonial era is apparently contradicted by recall data for onset of menarche in women in this Mazvihwa sample.[23]

Unfortunately the available child anthropometric surveys from the 1960s and 1970s, and since Independence (see Chapter Five, Footnote 6) are insufficient and of too varied method to make considered data-based statements about recent changes. However, there is a suggestion that there has been a decline in malnutrition in the Communal Areas since Independence,[24] but the same national level data have been interpreted both as showing a further improvement between 1982 and 1984 (Zanu, 1985:195-6), and for showing no change (Loewenson and Sanders, 1988:146). However, surveys on commercial farms,[25] mines and urban areas,[26] provide some evidence that rising incomes and living standards in these areas since Independence have improved nutritional status (reviewed by Loewenson and Sanders, 1988:147).

Even if the sketchy evidence available suggesting a decline in nutritional status during the colonial period and an improvement since independence is accepted, it would still remain difficult to identify precise causes, since longtitudinal studies of development projects, or places where there have otherwise been considerable socio-economic change, have often failed to show changes in nutritional status.[27]

One nutritional factor since Independence have been the child feeding programmes. Though there were programmes in the 1970s and possibly earlier, sponsored by organisations such as the Rhodesian Freedom from

Hunger association, and the programme investigated was shown to have beneficial effects (Theisen, 1978b), it was the extent of the post-Independence operations that make their impact of national significance. Feeding programmes implemented by UNHCR and Oxfam after the war were on a very large scale.[28] Oxfam targeted supplementary feeding at children with arm circumference below 13cms, and though there was no programme within the actual study area, a programme in neighbouring Mberengwa involved 7654 children in March 1981 (Sanders, 1981:13). Those programmes that were evaluated (eg. Chirumhanzu, to the immediate north of the study area), indicated that feeding did lead to a gain in weight after three months. Differential gain was shown by children with different levels of attendance and with controls, and together with the effects of a good harvest in 1981, the exercize was concluded to have improved nutritional status (Sanders, 1981:13 and 45-56).

During the 1981-4 and 1986-7 droughts the Government implemented national drought relief and child supplementary feeding programmes (Loewenson and Sanders, 1988:140-1; Holland, 1989) that far surpassed the efforts in previous years (cf. Appendix Two; Holland, 1987; Iliffe, 1990). These programmes focused on the drier regions of the country (Gaidzanwa, 1986; Weiner, 1988:70-1), in which the study area lies, the places where the crop yields were reported as the lowest. There were some problems in implementation (delivery and distribution), and it was reported that children sometimes declined in nutritional status once taken off the feeding programmes, but the exersize was by and large successful (Ministry of Finance, 1983; Holland, 1989). At its peak, child supplementary feeding involved over a quarter of a million children (Zanu, 1985:196; Loewenson and Sanders, 1988:141), and in the view of Sanders and Davies (1988:202) the drought relief and supplementary feeding programmes were critical in preventing a decline in nutritional status in the adverse economic and ecological environment of the 1980s.

Attempts were made to target food aid to the needy sectors of the population in the drought relief programmes. In 1986 in Matabeleland, for example, food aid was not granted to those with six to eight cattle or above, those participating in irrigation schemes, or those formally employed (Sibanda *et* *al.* 1986:64-5). More commonly, and certainly during Mazvihwa in 1986-7, the only disqualifying regulation enforced was that dependents of wage labourers should not receive food aid. (Occasionally, early on in the 'famine', rich farmers were denied it by community pressure on an ad hoc basis.) Much of the drought relief programme in the second period (1986-7), in which there was no direct child supplementary feeding (at least in Mazvihwa), was administered on a food-for-work basis in which money was dispensed (Z$2/day, per household), with one person working per household.)[29] In a study of food aid disbursement in neighbouring Chivi during 1981-4, Leys (1986) reported generally efficient distribution to the needy, but drew attention to the rural salariat (1986:258-9) and the importance of wage incomes to rural inequality in access to food in rural Zimbabwe.

Despite the size of these operations, and the enthusiastic reception that they have had from the rural population, the level of impact on household food availablity was not large, particularly in the second drought period (1987). Detailed research should be conducted, but I doubt that it ever contributed more than 25% of even rural poor people's food intake by value.[30] Furthermore, I have found that even though severe drought does harm sandveld communities economically (though not as much as those on clayveld), the impact on nutritional status in this zone is negligible (if not positive), because of the way that drought improves 'disease environment' (Chapter Five, Section 5.3). Therefore the overall impact of the feeding and drought programmes is rather uncertain, probably fairly small, but possibly significant for the poorest population sections.

Effect of increased birth control on infant mortality

Birth control is viewed as directly contributing to reduced infant mortality in a number of ways, as well as having a synergistic interaction. Since there is growing use of contraception in rural Zimbabwe since Independence (see Section 9.2), it is important to briefly consider whether this might also be contributing to reduced mortality. Recently, Bongaarts (1987) has defined the direct relationships between contraception and infant mortality more clearly, but argued that those factors reducing mortality are actually countered by others than increase mortality. The improvements defined by Bongaarts were the reduction in teenage births and the number of births of seventh order and above. (There is no data on mortality rates for teenage births in this population, but higher mortality rates in birth orders over seven are indeed found in Mazvihwa, see Chapter Seven, Section 7.3.) Contraception in Zimbabwe has had little effect upon teenage births as it is basically not provided to unmarried women (see Section 9.2), and women generally do not marry until at least twenty. Anyway, there are few teenage births in this population: the 1969 and 1982 censuses and the Mototi study each observed age-specific fertility of 0.3 for the 15-19 age-group (just 5% of mean completed fertility). Recent extension of contraception does seem to be lengthening birth-interval above fifth birth (Section 9.2), and the effect of this will be to lower the number of children of seventh birth order and above, and hence to reduce overall mortality. Bongaarts (1987) claims that contraception leads to more irregular birth intervals hence increased mortality. Yet as pointed out by Trussell (1988) this is the result of a spurious interpretation of comparisons between countries. High contraceptive-using third world countries tend to be those where there is less breastfeeding and consequently shorter and/or more irregular birth intervals anyway, independent from contraceptive use. Longer birth intervals (Section 9.2) will also reduce mortality (Chapter Seven, Section 7.3). Bongaarts (1987) observes that successful birth control will lead to first births being a greater proportion of total births. According to his argument, first births tend to show higher mortality, and hence lower overall fertility will lead to increases in IMR. Yet such a relationship is not shown in the Mazvihwa data, Chapter Seven, Section 7.3, and in certain social situations first births may not show higher mortality.[31]

Changes in Welfare and Mortality: Data and Discussion

Evidence for changes in infant mortality rate in the Mototi and Mutambe sample studies is presented in Tables 9.1.1 and 9.1.2.

Table 9.1.1 Decline in Infant Mortality Rate Since Independence (Mototi sample only)

Year	n born	n died	IMR
1935-49	33	5	152
1950-79	368	41	111
1980	26	5	192
1981	24	2	83
1982	28	3	107
1983	25	2	80
1984	14	1	71
1985	32	2	63
1986	14	1	71
1987	18	0	0
1981-7	155	11	71

Notes to Table 9.1.1:
These figures are based on those women for whom the most reliable information is available, and they themselves are still resident within the sample. Deaths of under ones are not hidden for any reason. In 32 births I myself monitored prospectively in 1986 and 1987 only one died (as a neonate 24 hours after birth in the district hospital). On this day the research team were obliged to stop work to go to the home and give matambudziko (condolences). The IMR in monitored children was thus only 31. 1980 is separated from the other data as the rate is very high. Independence actually fell in April and 1980 can be seen as a period of transition. There is some suggestion of lower mortality after 1893.

The mortality reduction from 1950-79 to 1981-7 is not statistically significant (χ^2 1.99, 1df. p<0.2).

Table 9.1.2 Decline in Infant Mortality Rate Since Independence (Mutambe sample only)

Year	n born	n died	IMR
1960-79	297	32	108
1980-86	139	7	50

Notes to Table 9.1.2:
Data prior to 1960 were not considered reliable enough in this 'one-off' survey, without the multiple checking methods and local knowledge that was the case in the Mototi study.

1980 did not show elevated IMR in the Mutambe sample so it was included with the post-independence period. 1987 was excluded as most of the children born in 1987 had not reached one year in February 1988, the time of the survey. Only in Mototi have these children been continually monitored up to September 1988 (by A. Mawere Ndhlovu) when all had reached one year.

The decline is almost significant at the 5% level (χ^2, 3.79, 1df.)
Combining the data from Table 9.1.1 with that from 9.1.2 the IMR change is from IMR 110 to 61/1000, and this difference is statistically significant (χ^2 5.59, 1df. p<0.02).

My material on changing mortality is now compared with the estimates of mortality in the Zimbabwe literature (Table 9.1.3).

Table 9.1.3 Comparative Mortality Rates for Zimbabwe from the Literature

Authority	Year and area of survey	IMR <1yr/1000	Child 1-5yrs/1000
	DATA PRE-1950		
Beach (1988)	Quoting early NC estimates	500	
Dadaya Mission (Sept 1935)	Zvishavane rural area (guess for report)	500	
Shaul (1955a)	National 1948 Provinces 1948	131 range 89 to 153	
This study	1935-1950 all women optimum sample	 132 152	 132 152
	DATA FOR YEARS 1950-1979		
Shaul (1955b)+ Shaul and Myrbrugh (1956)	14 Districts 1948 14 Districts 1953	123 + or - 31 120 + or - 21	
UNICEF (1988)	1960 Estimate	110	72
Mzite (1981) in C.S.O. 1985)	National census 1969	101	
Brydone (1975)	Mufakose Tship/Hre 1970-2	18	
Mossop (1979)	Kadoma township 1963: Kadoma Township 1973:	80 28	
Stoughton (1975)[32]	Bikita hospital 359 women in 1972 results equal before/after 1967	68	62
Theisen (1976b)	Chiwundura rural 'unstressed' to 'stressed'	120 to 250[33]	
Zanu PF (1985) Loewenson and Sanders (1988)	Official pre-independ. figures (rural), pres. late 1970s	120 to 200	
Agere (1986)/ Gilmurray *et al.* 1979	National data, source unknown, pre-indep pres. 1970s	120 to 220	
Thomas *et al.* 1979	Population Reference Bureau (UN) pre-indep	122	
Waterston and Sanders (1984)	National data, source unknown, pre-indep	120 to 150	
Raath (1985)	National data, source unknown, pre-indep	140	
Loewenson and Sanders (1988)	Offical pre-independ. figures (urban)	50 to 90	
This study	Mototi 1950-79 Mutambe 1960-79	111 108	41 34

Table 9.1.3 Continued
DATA POST-INDEPENDENCE (1980)[34]

Authority	Year and area of survey	IMR <1yr/1000	Child 1-5yrs/1000
National Census (C.S.O. 1985)	Raw data 1981 + 1982 retrospect from 1982	28 80 to 90	
Zanu PF (1985) Agere (1986)	Surveys with Unicef, Sida and WHO by Min of Health	60	
Raath (1985)	National estimate, source unknown	75	
UNICEF (1988)	National estimate, 1986	74	44
This study	Mototi 1981 to 1987 Mutambe 1980 to 1986	71 50	

The comparative data in the literature show a pattern approximately similar to that obtained in the Mazvihwa study. Mortality shows substantial declines pre and post 1950, and again pre and post 1980. National and Mazvihwan Infant Mortality Rates seem to show similar declines from around 110-120 to around 60-70/1000 in the latter period. Factors contributing to mortality decline in Mazvihwa may therefore be similar to those acting within Zimbabwe at a national level, but this remains unproven.

Evidence for the contribution of curative health services in Zimbabwe

It was shown in the introduction to this section that there have been marked improvements in health service provision in this area since Independence, and that in other areas of Africa provision of such services has had a marked effect upon mortality. I now review evidence that supports the notion that recent declines in infant mortality in Zimbabwe are a reflection of health service provision.

Clear demonstration of the contribution of curative services requires comparison of two otherwise similar populations only one of which is utilising health care. Without such comparison the simultanous education and economic changes cannot be separated from effects of health service extension. One simple method would be to identify neighbouring populations that are provided with very different levels of health care, as was done by Orubuloye and Caldwell (1975) in Nigeria. This is not presently possible in

Zimbabwe because of the government policy of even spreading of primary health care. Only on a regional basis are there significant differences in services, but these tend to be compounded by general differences in economic development and disease environment which invalidate the comparison (see earlier for discussion of the importance of disease environments).

In this study I can make use of the fact that there is a religious minority (Apostolics) who refuse to use the services provided by government. That this is not simply a normative value statement is demonstrated in 'response to morbidity' data (Chapter Eight, Table 8.3.18). It is indeed the case that since Independence this group has experienced higher infant mortality (Chapter Eight, Table 8.1.4.9). Correlations between Apostolic religion, wealth, education and other factors are insufficient to explain the result (Chapter Eight); and the result is plausible in the light of the limited literature available (Chapter Eight). However, it should be noted that children in this Apostolic group also experience diarrhoea more frequently, and, furthermore, several related families in this group are responsible for the mortality effect. Therefore elevated mortality might possibly be a function of familial factors. Yet it remains reasonable to consider higher mortality amongst a population group that does use western medical services to be evidence for the importance of those services.

Although there is evidence for the importance of health services from the studies of maternal religion, analysis of disease treatment differentials by wealth suggests that the use of health services is <u>not</u> the cause of the very low mortality rates amongst the rural wealthy since Independence in the clayveld population, though it might be in the boundary sample (Chapter Eight).[35] Empirical data from Mazvihwa are not available to test which particular compenents of health service provision are responsible for changes (if any).

To conclude, therefore, there is some evidence that improvements in health service provision have contributed to declining mortality since Independence. Furthermore the previous mortality threshold, that of 1950, may also correspond to a period of rural health service improvement (see introductory discussion). As far as evidence for changes in underlying nutritional status are concerned, the evidence is weak, but there may have been an improvement. Even if there has been an improvement, it is not known whether this is great enough to significantly improve morbidity (for review and data see Chapter Six, Section 6.4) or mortality (see review Chapter Seven, Section 7.2). If maternal nutritional status or height has changed then this would, however, be expected to have an impact on birthweight (Chapter Five, Section 5.1) and infant mortality (Chapter Seven, Section 7.2).

The impact of education and wealth on recent advances in welfare

Socio-economic changes - especially those associated with increasing female autonomy such as education - can have marked impacts upon mortality (see introduction, this section). I now examine the evidence available from this case study to assess the contribution of such social change. As has been argued in the introduction, changes in social status variables (eg. number of years of maternal education), cannot be understood outside of analysis of changing social organisation, orientation and attitudes. Specifically, the advances in the confidence and aspirations of women since Independence could be transforming mortality levels whether or not 'status' measures change.

Maternal education was found to have very marked impacts upon mortality (Chapter Eight, Section 8.4). An important relationship found was that the infant mortality rate (IMR) for women of given education was basically similar before and after Independence (Table 8.4.6). (Indeed, if anything, women who were illiterate or had little education had a slightly higher infant mortality rate after Independence than before.[36]) Therefore the reason for lower mortality, at a population level, could be that there are now a greater proportion of women at higher levels of education. Whereas before Independence (1980) the proportion of babies born to women with over three years primary schooling was just 28%, since 1980 the proportion has been nearly 60%. This would locate the roots of the advance in infant mortality post-1980 in the expansion of primary schooling in the pre-Independence and immediately post-Independence periods. It must be noted, however, that there was no fall in infant mortality until Independence was actually attained. A greater proportion of births by younger and more educated women would also reflect the use of contraception by older women to limit the number of high birth order children (see Section 9.2).

If such a relationship between education and mortality holds in the 1990s and after the year 2000, then the spread of universal primary education could mean that IMR will fall further, perhaps to as low as 40/1000. Whilst such a low IMR may seem implausible in rural Africa, a rate as low as 49 was achieved in non-malarious eastern Kenya in the late 1970s (Omonde-Odhiambo *et al.* 1984:221). But it should be noted that other public health problems - notably AIDS - might make this hope impossible. Between October 1985 and March 1987, 188 children who were HIV positive were identified by the health service in northern Zimbabwe (Topley, 1988). Despite some public education, which has improved the situation from one of near total ignorance (cf. Wilson and Wilson, 1987) to one where most adults know and fear the disease (Cornwall, 1990:102), there may unfortunately be too little change in sexual behaviour in Zimbabwe (as in many other parts of the world) to control the epidemic.

Rainfall has been relatively low since Independence (Chapter Three). The impact of this on nutrition, morbidity and mortality is only negative in clayveld populations (Chapters Five, Six and Seven). Infant mortality since independence has been lower on sandveld (both in Mutambe and within the Mototi sample) than on Mototi clayveld; which presumably reflects effects of rainfall. If the predicted return to high rainfall occurs in the 1990s (Tyson, 1978), clayveld populations would be expected to make further advances in IMR decline, whilst sandveld infant mortality rates would worsen a little. Furthermore, wealth differentials in mortality might be expected to decrease in clayveld, but increase in sandveld, reflecting birthweight differentials (see Chapters Five, Seven and Eight).

Since female education also rose from negligible to minor in the period leading up to the mortality transition point of 1950 (see introduction), education may also have combined with health services to facilitate the previous mortality transition.

Consideration of the association between education and Infant Mortality Rate should be interpreted in the context of the fact that maternal educational status had a much stronger effect on mortality amongst the poorest households (Chapter Eight, Table 8.4.8). Additionally, wealth rank has an independent and marked effect upon mortality (Chapter Eight, Tables 8.4.2, 8.4.3 and 8.4.4). The relationships of mortality with wealth, and the fact that it is methodologically impossible to examine changing relationships between wealth and mortality (see Chapter Eight), mean that the impact of changing economic conditions since Independence and in future years cannot be examined as mortality change determinants. Whilst there clearly are interactions between education and wealth mortality differentials and the level, type and use of health treatment facilities, it should be noted that like wealth, education shows only weak (though interesting) relationships with child morbidity and treatment of sickness (Chapter Eight, Section 8.3).

A large, carefully stratified statistical survey on the relationships between rural and urban maternal education in the context of wealth differentials and maternal religion would be valuable in Zimbabwe. Combined with careful retrospective analysis, this might predict mortality trends quite well if contextualised within study of educational and economic change. However, the intermediate variables which actually 'cause' the mortality relationships also require research, especially so as to throw light on the contribution of different components of health service extension. The fact that the self-esteem of rural people was greatly elevated by Independence should also be considered, even though it does not fit easily into the analytic framework.

Conclusion to Section 9.1

Literature review suggests that significant and rapid changes in infant and child mortality can be achieved in the absence of general economic growth through a combination of socio-economic change to the advantage of the poor in general, and women in particular, combined with effective health service provision. It is then shown that Independence in Zimbabwe (1980) fulfilled some of these conditions. This marked socio-political transformation, provided some nutritional benefits to the poor, and made an enormous improvement in rural health services, including with contraceptive extension. Empirical data for Mazvihwan women addressing infant mortality differentials <u>between</u> women (before and after Independence) suggests that the halving of infant mortality occurring in Mazvihwa is basically the result of increased maternal education and the greater availability and use of western health services. It seems likely that similar factors are operating nationally.

9.2 Changing Patterns of Fertility

Introduction

This section examines evidence that there has been a reduction in fertility since Independence (1980), as a function of the transformation of a combination of social, economic and technical (contraceptive extension) factors. It is thus argued that changes in fertility are occurring in tandem with the reductions in infant mortality described in section 9.1. In this way a cycle of accelerated population growth initiated, perhaps, by increased fertility and especially declining mortality, both little understood, (cf. Iliffe, 1989), is now being slowly brought to a close. In this section I first present a brief review of material on changing fertility in Zimbabwe, then present some of my own data on fertility, marriage rate and birth interval changes, and finally discuss these results and their possible significance.

A Changing Pattern of Fertility: Literature Review

Data on completed fertility for Zimbabwe is sparse, and critical discussion of changing fertility determinants virtually non-existent. In this review I will first examine the limited data from the literature, in order to make the argument that there may have been an increase in fertility in Zimbabwe from the middle of the colonial era until Independence. Next I explore material on rural fertility determinants, and how these have interacted with indigenous and western 'contraceptive' use, before, and following, Independence (1980), to argue for a likely decline in decline in fertility in recent years. Finally, I present and discuss some data to demonstrate several of these points empirically for my population.

Data in Table 9.2.1 suggest that completed fertility may have increased from around six live births in early colonial period, to around seven or more in recent years.[37] Even in the data for the study sample there is some evidence for a historical increase in fertility - though only for sandveld. The number of live births achieved by women born between 1913 and 1937, (6.1 children), is less than that for women born between 1938 and 1947 (8.0 children). (There is evidence that this is <u>not</u> due to more complete reporting amongst younger women: see section 'Problems with Analysis in Table 7.1.4.1' in Chapter Seven),[38] though the quality of the data do certainly leave something to be desired. For some analysts this kind of result is regarded as key to driving population growth in the period in question reflecting changes in labour demand and gender/ lineage relations (Iliffe, 1989) an attractive argument requiring vastly more empirical research; for others, however, it is of relatively little significance, just: 'A common phenomenon in Africa and elsewhere in the early stages of demographic transition' (Caldwell, 1984:20), reflecting a relaxation of the 'traditional' controls on fertility (cf. Page and Lesthaeghe, 1981). Indeed in a sub-sample of women interviewed in this sample there was some evidence for shortening post-partum sexual abstinence through time (Cornwall, 1990:58).[39] Therefore the increase in fertility in the colonial period may be largely a by-product of social change rather than the result of conscious changes in the desired number of children. This remains unknown, however, and should be considered along with other possibilities.

Table 9.2.1 Comparative Fertility Data for Zimbabwe in the Literature

Authority	Year and area of survey	Total fertility per woman
Beach (1988)	Quoting early NC estimates	6.0
Shaul (1955b)	17 districts in 1953	5.7
C.S.O. (1985)	National Census 1969	6.9
C.S.O. (1985)	National Census 1982	7.2
This survey (Mazvihwa + Mutambe)	Women presently aged 50-74	
	Sandveld (n=32):	6.1
	Clayveld (n=16):	9.4
	Women presently aged 40-49	
	Sandveld (n=30):	8.0
	Clayveld (n=13):	8.8

One other possible contributing factor would be changing female nutritional status (for a review of the possible effects of this see Chapter Seven, Section 7.1), since there is some evidence for earlier menarche (Section 9.1) that might be reflected in better nutritional status throughout reproductive life. But with present evidence this is probably unlikely. More likely to be significant has been some control of syphilis and other venereal disease that were causing sterility.[40] It should be noted, however, that these diseass were introduced into most of Zimbabwe only in the 1890s (oral history and Gelfand, 1976:24-5), and therefore presumably acted during the early colonial era to depress fertility levels relative to that experienced in the pre-colonial period. Measures employed during the 1920s-1940s were having some significant effect on incidence and the impact of sexually-transmitted infections (Gelfand, 1976:34), and therefore the increasing fertility of the 1960s-70s may indeed reflect in part a reduction in sterility.

Determinants of Fertility in Southern Zimbabwe and Contraceptive Extension: a context

The tendancy in the literature has been to see Africans as essentially pro-natalist,[41] and African fertility levels as a function of marriage patterns and birth interval control through lactational amenorrhea (eg. Hill, 1985). Whilst this may be true in some populations, important evidence exists for this Zimbabwean population showing that the population actually exercizes a more active control of fertility. Whilst the mean interval between the previous birth and next conception is around 22 months, the mean length of post-partum lactational amenorrhea, though variable, is just eleven months (Cornwall, 1990:58), furthermore, as many as 18% of women reported conceiving at least once prior to the return of menses (Cornwall, 1990). Whilst around six months of sexual activity may be necessary to become pregnant (Retel-Laurentin and Benoit, 1976:292), this still leaves around five months unaccounted for. Breast feeding in rural Zimbabwe continues for around 16-19 months (Cornwall, 1990:58; Zimbabwe Reproductive Health Survey, 1986, quoted in Cornwall; Edmonstone, 1984:156).[42] Due to a fear of **kumwira**, a folk disease of diarrhoea attacking a suckling infant when a mother is pregnant (see Chapter Six, Section 6.1.4), women try to avoid pregnancy whilst breast feeding, and almost always wean as soon as they become pregnant (see also Cornwall, 1990). It is, therefore, success in avoiding pregnancy during breast feeding that explains long birth intervals in this data.[43]

It should be noted that avoidance of pregnancy during lactation is not achieved through post-partum abstinence, as this lasts only a mean of around four months (Cornwall, 1990:58), hardly longer than biological post-partum infertility. In the past it has been achieved by the use of *coitus* *interruptus* during lactation (Wilson, 1986e; Cornwall, 1990), combined with symbolic and medicinal charms that the medical student I worked with (A. Irene Masanga), believed might possibly reduce fertility through psycho-somatic influences (Wilson, 1986e), though this is, of course, doubtful (Cornwall, 1990). Although such active control of fertility may seem unlikely, and the result of "idealistic anthropologising", it is worth recording that similar arguments have been made by a Native Commissioner well known for his detailed interest in African rural life, and a Rhodesian family planning health official.[44] This existing system of *coitus interruptus* also helps to explain how in recent years the pill has become used to great effect in this regard (see below).

A further critically important issue in the underlying capacity of this society to achieve fertility control is that of conflicts of interest between men and women. Women are much more frequently concerned to lengthen the birth interval and to keep family size manageable than are men (Wilson, 1986e; Cornwall, 1990). Clarke recorded of an extension meeting that 'One of the women stood up and said most women wanted family planning but the main trouble was with their husbands' (1971:19). Such conflicts of interest are central to domestic debate in Mazvihwa, and framed by over-arching social requirements of men to expand home and lineage, and women to balance their own and existing children's well-being against their obligations as wives (see also Cornwall, 1990). In the examination of the success of contraception post-Independence this theme will re-emerge, since it appears that a shift in the balance of power towards wives has been equally as important as economic change and contraceptive availability in reducing fertility.

Contraceptive availability in rural Zimbabwe has historically been rather limited. During the rule of the white-supremacist Rhodesia Front (1962-79) the desire to curb African population growth rates acted as a major boost to family planning extension. However, this was implemented through the Family Planning Association, a voluntary body (though Government assisted) that was founded largely with a sincere concern for the positive benefits to be derived by women from family planning. Between 1973 and 1975 there was a 60% increase in the number of women dispensed with contraceptives, and nearly a third of fertile urban women were covered (Davies, 1976:153), or 20% of women 'at risk' according to Castle (1976:148). The injectible, Depo-provera was the contraceptive of choice being about one third that dispensed in 1974 and one half in 1975 (in Harare), according to Davies (1976:153), and two thirds of contraceptives dispensed in urban areas at that time according to Castle (1976:148). There was little extension in rural areas, where, even in Mashonaland, just 2.7% of the women 'at risk' of pregnancy at any one time were using contraceptives (Castle, 1976:148), largely due to poor extension and supplies (Castle, 1976:149). In the last years of the war use rates were maintained or increased in the urban townships (Castle and Hakutangwi, 1979:127), and in the rural areas (Pugh, 1978e:123), and depo-provera remained the contraceptive most frequently used, although the pill was also used. According to data collected by Cornwall (1990:Figs 2-4, Chapter on Contraception) during 1979 9% of women had used the pill and 9% depo-provera since their last birth.

At Independence (1980) there were marked changes in contraceptive extension policy. Depo-provera was withdrawn as it had come to symbolise technocratic control over women's fertility by white state science rather than by African lineages and/or political nationalism. Furthermore, there were numerous cases where women had been injected without their prior consent or understanding, and/or afterwards they had failed to conceive for extended periods of time (S. Nyoni, pers. comm. 1980). Some more technical factors may also have been involved in its withdrawal (A. Cornwall, pers. comm. 1990). Thus there was an initial marked fall in contraceptive use (cf. Edmonstone, 1984:156), which was curbed by the formation of the parastatal Child Spacing and Family Planning Council (1981), which later became the Zimbabwe National Family Planning Council (Loewenson and Sanders, 1988:141-2). Massive extension of oral contraceptives was then initiated through 'bare-foot' Community Based Distributors in the villages, programmes through schools and the media, and through clinics and hospitals (Zanu, 1985:194; Cornwall, 1990). The programme reflects, in part, a sense in Government (and especially the civil service) that Zimbabwe is already over-populated and headed for ecological and economic disaster unless growth is contained. The family planning programme has operated with astonishing success. According to UNICEF (1988:76), between 1981 and 1985 Zimbabwe achieved 40%

prevalence amongst women 'at risk' of pregnancy, which has been touted as the highest rate of contraceptive use in Sub-Saharan Africa (Loewenson and Sanders, 1988:142).[45] However, problems of contraceptive extension remain due to inadequacies of basing extension on simplified versions of western scientific explanations rather than building on indigenous conceptions of fertility, leading to both some mis-use and also some fear and resistance to contraceptive use (Cornwall, 1990). In addition women will require more rights if they are to reduce fertility to the level which they desire (see also Cornwall, 1990), and unless there are further economic changes there will be little incentive to reduce family size below five births.

I will now examine material on the determinants of desired fertility, how these interact with contraceptive use, and reasons why there may be changes in this since Independence. The only previous work done outside of a family planning framework in Zimbabwe was the innovative research of Theisen (1977) in Chiwundura Communal Area. Although his analysis is difficult to unravel or replicate, the thrust of the work is clearly insightful. He suggested that variables providing psycho-social 'security' would be key in lowering desired fertility. Thus the number of children seen as desirable by women will vary with their whole circumstances, which are the result not of the state of one variable in isolation (such as education), but of interacting variables that together facilitate stress or security. Nevertheless wealth and education were principal factors promoting 'security'. Theisen quotes field data derived from applying his 'stress scale' which suggest that increased 'security' markedly reduced fertility. Theisen also found lower fertility amongst the most 'stressed' women, which he alleged had a physiological basis (see Chapter Seven, Section 7.1 for a review of literature on this possibility).

A survey in a Harare township (Glen Norah) undertaken in March 1977 found that the contraceptive using women had richer husbands, thus indicating that economic factors contribute to desire for reduced family size in urban as well as rural areas (Castle and Hakutangwi, 1979:127-9).

Work in Mazvihwa indicated that both maternal education and wealth have a marked influence upon desired family size, and hence contraceptive use. More educated women desire much smaller family sizes than the illiterate and less educated (Cornwall, 1990). This relationship would tie in to concepts of modernisation and changing outlook, as well as factors reflecting an altered balance of power within the household, enabling women to articulate their desire for a smaller family with greater chance of success (cf. Chapter Eight). Cornwall (1990:87) found that there were considerable differences in contraceptive pill use rates with maternal education. Just 10% of the illiterate women in her small sample utilised the pill, 33% in those with basic literacy, and 50% of women with five years of primary schooling or above. Cornwall observes that the Zimbabwe Reproductive Health Survey also found that that literate women have higher contraceptive use rates.[46]

Household wealth in Mazvihwa also appears to affect the desired number of children, and propensity to use contraception. Of thirty one women asked (in 1987) whether the relatively poor or wealthy wanted more children, twelve (39%) said there was little difference, but sixteen (52%) stated that the poor wished for more children (and/or would not regulate the number of births), compared to just three (10%) who thought that the rich wanted more children.[47] Furthermore, amongst twenty seven women interviewed about whether it was time to increasingly regulate fertility, 78% of the wealthiest said that it was indeed appropriate to reduce family size, whilst 75% of the poorest were against more regulation.[48] However, results obtained by Cornwall (1990:63-4 and 86) with a slightly different sample of women and different questions, produced a less clear result.[49] The main reason for the difference in desired family size between the wealthy and poor is neatly summed up in the following quotations from women interviewed in 1987:

'the poor need more children to give them more chance of one getting employment and escape from poverty'
'the poor want to be raised up by their children, and the rich don't need that'
'Poor people have more children as they hope that one will get rich and make them rich too'

Desire for family planning since Independence has increased not only because of higher levels of female education, and greater incorporation into the national economy leading to a rural elite response to modernisation (cf. Section 9.1),[50] but also because of marked changes within the economy of the Communal Areas. It was noteworthy that ecological stress, and constrained access to such resources as arable land, were little cited as the principle reasons for the need to reduce fertility.[51] In fact it was the cost of bringing up a child in 'the new Zimbabwe' (as people say), especially the costs of school fees, and of clothing (etc.), that was most often reported as critical. Pugh, the Medical Officer for Matabeleland North, also reports that the economic pressures of the cash-economy (especially urban housing and education) are responsible for the decline in numbers of children wanted and the resulting enthusiasm for contraception (1987:105).[52] I believe that the reason why these cash needs have assumed so much importance since Independence is largely a function of people's higher expectations per child, and hence the amount of investment that they need to make. The optimal number of children for a family was given in the 1987 study as anything from three to eight, but four was the most common number stated, followed by six. One woman who wanted four pointed out: 'Some husbands sympathise with women but not most'.[53]

Despite a marked trend to desiring smaller family size since Independence, it should be noted that a large proportion of the Mazvihwa population are still outwardly against contraception. Indeed, in my 1987 survey a greater proportion of women (48%) said they were against regulation than in favour (33%) (n=27 women); but it should be noted that the sensitivity of the topic means that little store should be put in the exact figures, and in another survey with this sample many women who initially stated that they were against family planning later admitted to using it (A. Cornwall, pers. comm., 1990).[54] The most common reasons articulated against family planning were 'religious', for example: 'Only God is to decide the number of children people have: he will decide what to do with them all, rather than us scratching our heads over it!'. But the interactions between religious belief, desired family size, and practice are extremely complex as is illustrated by the following quotes from women in 1987:

'It will be judging the Creator to intentionally limit family size, only the greatest of troubles will lead people to do it; but we are facing those now'

'I would like to have only six children. However, as I do not believe in birth control you may come back and find me with ten children'

'God decides. He can give you anything from five to fifteen. But now with school fees it is time for us to regulate . . . '

Greater acceptance of the pill will result if extension methods can overcome resistance based on various negative stereotypes, particularly that it gives women sexual freedom, damages their **mafundo** (ova) and menses, and weakens male sperm/virility (see Cornwall, 1990, for detailed argument and possible remedies). The pill is also facing problems of credibility because of misuse by women resulting in pregnancies. These are due to misunderstandings of the inappropriately western scientific extension messages, which are creatively interpreted by the extension agents and users in ways that lead to incorrect usage (Cornwall, 1990). But adoption by certain religious groups in this area, notably Apostolics, is likely to remain very low (as it is at present, Cornwall, 1990:87-8).

It has been shown above that there is desire for contraception to meet two somewhat different needs. The first is to maintain birth intervals sufficient to allow the completion of breast feeding (around eighteen months), without having to rely on the existing system of *coitus interruptus* which is both less pleasant and less reliable. A second requirement, which has potentially greater impact on actual fertility at the population level, is to prevent further pregnancies once desired family size is reached (see also Cornwall, 1990). The significance of this second factor was also concluded in two other studies of contraception extension in Zimbabwe. In the Harare township the women using contraceptives tended to be those who had already achieved desired family size, and that many non-users were simply waiting for their families to grow to that size (Castle and Hakutangwi, 1979:129). Castle and Saphire (1976:967) also reported that rural women in the Umvukwe (Mumvure) area wanted an average of 5.59 children, and attendance at family planning clinics began, on average, after five births. A similar birth-order timing of the decline (five to six births) was seen with the onset of contraception in Europe (J. Landers, pers. comm., 1988). However, two recent large surveys in Zimbabwe suggest that more women use 'spacing' than 'stopping'; though they do not calculate the effect of the two upon the birth rate. Chombo *et al.* 1986, who interviewed 3269 new acceptors in March 1985 found that only around 10% of women were 'stoppers', women who (again) had an average of around six living children already, and most of whom were over forty years old (mean age 34). The bulk of the women were 'spacers', with a mean 2.6 living children and an average age of just 24 years. Chombo *et al.* (1986:113) draw attention to the fact that the age/family size of wishing to stop having children may be declining. The preliminary examination of the 1988 Demographic Health Survey suggests that by far the highest percentages of currently married women using modern methods of contraception are between twenty five and thirty four (van de Walle and Foster, 1990:18), and are therefore mainly using contraception for birth spacing rather than for limiting family size.

Changes in Fertility Since Independence: Data and Discussion

Recent data from the 'demographic Health Survey' suggest that there may be reductions in fertility taking place in several African countries, including Senegal (possibly), Botswana, Kenya and Zimbabwe (van de Walle and Foster, 1990:10-17). Though the data are recognised as highly inadequate, the reviewers consider contraceptive extension in these countires as the key factor (van de Walle and Foster, 1990). This section now examines whether there is a decline in fertility in Mazvihwa since Independence, and, if so, the form that it is taking.

Given that there is is desire for around five children in Mazvihwa, it is is not surprising that the extension of family planning has caused a lengthening of the birth interval after the fifth birth (Table 9.2.2 and Graph 9.2.3).

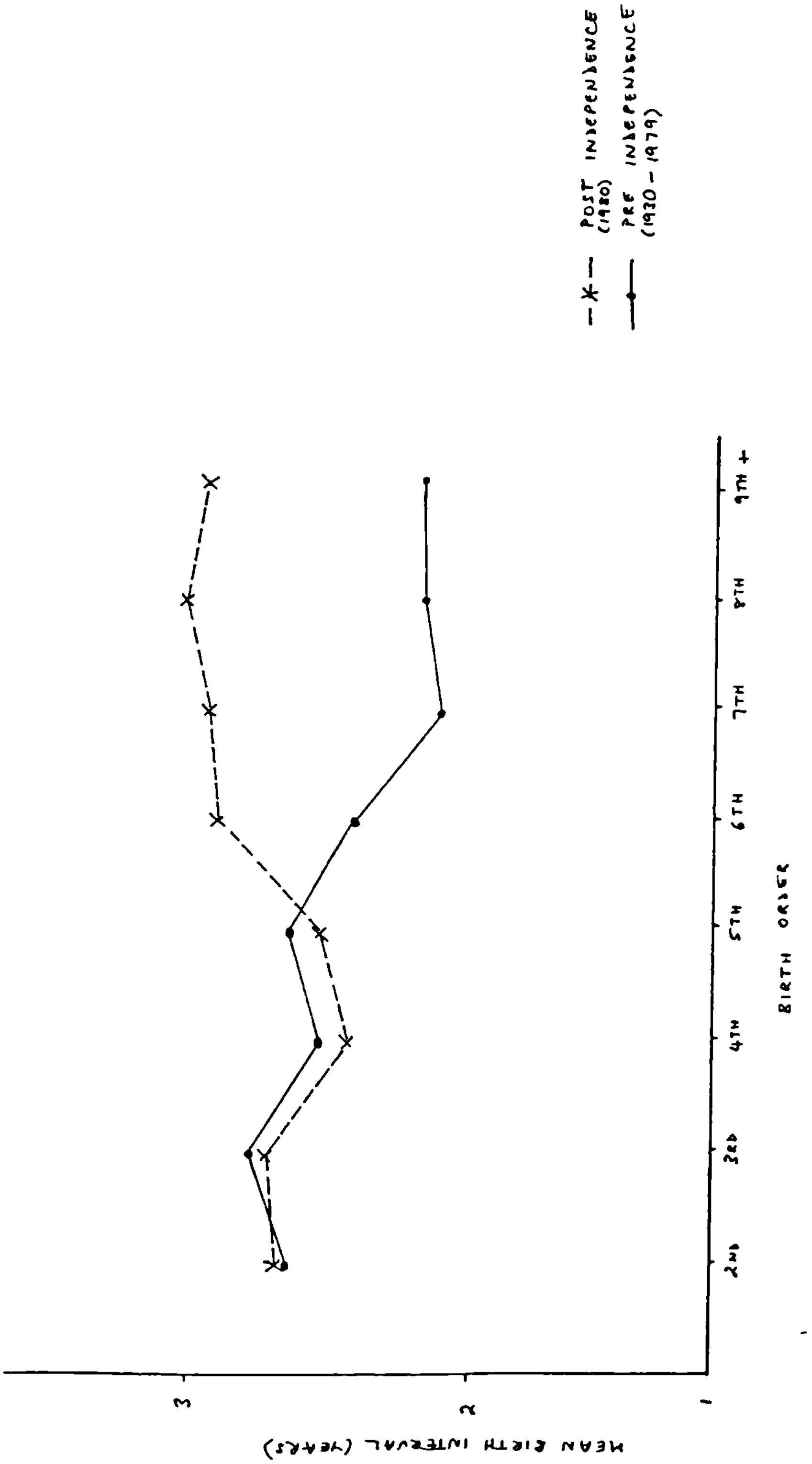
Table 9.2.2 Evidence for a Lengthening of Birth Intervals since Independence (1980)

Interval in Years	Pre-Independence 1	2	3	4	5+	mean interv	Post-Independence 1	2	3	4	5+	mean interv
Birth Order												
2	15	82	24	3	13	2,69	5	26	13	4	5	2,70
3	4	70	30	9	10	2,80	6	26	13	4	6	2,76
4	7	60	25	13	3	2,55	4	24	13	2	2	2,42
5	4	56	17	8	6	2,68	1	15	5	4	1	2,58
6	3	52	15	6	2	2,42	3	12	5	6	2	2,93
7	10	36	9	4	0	2,12	2	7	11	2	2	2,96
8	3	23	7	0	2	2,29	1	9	6	3	3	3,05
9+	4	34	8	2	2	2,28	3	14	14	3	3	3,00

Notes to Table 9,2,2:
Overall the birth lengths are longer post-Independence (1980) than prior to it (χ^2, 17,82, 4df, p<0,01). This lenthening is equivalent to about 8% longer birth intervals. Nearly all the lengthening in intervals following Independence is in the post fifth-birth intervals. The contrast between pre- and post-Independence for these births is highly significant: (χ^2, 28,33, 4df, p<0,001), and these high birth-order intervals are now around thirty per cent longer than they were prior to 1980.

This data is also presented as Graph 9,2,3

FIG 9.2.3 EVIDENCE FOR A LENGTHENING OF BIRTH INTERVALS SINCE INDEPENDENCE (1980)



A fairly similar result to that in Table 9.2.2 and Graph 9.2.3 was obtained in a more careful analysis of a smaller sample of these women, (though perhaps somewhat biased towards the contraceptive users), undertaken by Cornwall (1990:56, Tables 1A to 1C), using data for 1980 to 1989. In this other study mean birth interval following Independence for the second to fifth birth was around 30 months, intervals preceding sixth births a little longer, and intervals for seventh birth and over 40+ months. A particularly important finding by Cornwall (1990:Fig 2, Chapter Two; Fig 5, Chapter Three) is that for the interval preceding the second to six birth, users of the pill had only slightly longer birth intervals than other women relying on *lactational amenorrhea* or *coitus interruptus*; but that the seventh and over births had birth intervals of an average of 55 months in the case of pill users, 28 months for women using *coitus interruptus* and 24 months for those relying on *lactational amenorrhea*. Given that this analysis ignores women who successfully use the pill to never become pregnant again, the figures well illustrate how women in different situations are effectively using the pill in entirely different ways. As is pointed out by Cornwall (1990), the use of the pill to end fertility is not particularly medically sensible, but she also found that there are few other possibilities, given that the measures must be easily reversible if the woman needs to have more children later.

Lengthening birth interval only after the fifth birth may seem not very significant for the regulation of population growth, when the average number of births in this population is only around eight. The degree of lengthening interval was about 35-40% in my own data. If all women had the same (average) number of births, and ceased to give birth at the same age as previously, the effect would therefore be to reduce total fertility by just over one child, or around 14%. However, due to the fact that there is a skewed distribution of births, considerably more than 3/8 of the births have been born beyond the fifth birth order, and therefore the reducing effect on fertility is more significant.

A second factor reducing fertility since Independence is later marriage, which is related to education. Women are now expected to complete eleven years of schooling (see Section 9.1), starting from an age of around seven years, with, in general, one or two 'repeat' years. This means that the bulk of the female population only consider marriage from the age of around twenty years, when this had previously been approximately the mean age of marriage (Chapter Seven, Section 7.1.4; see this section and also below for the somewhat ambiguous evidence for current later marriage and pregnancy). Age of marriage also appears to be affected by economic changes. The costs of bridewealth continue to inflate rapidly in the national economy (cf. Chigwedere, 1982:11), whilst marginal areas like Mazvihwa have faced droughts that have severely depleted livestock capital and led to years of poor crop harvests; the droughts have been so severe that even the sandveld zone has suffered economically (see Chapters Three and Four). The effects of this are illustrated in Table 9.2.4 that compares marriage rates in Mazvihwa before and after Independence.

Table 9.2.4 Marriage Rates Before and After Independence

Years	Number of men/yrs (aged 20-59) (for each year then summed)	Marriages	Marriage Rate Per man/year
1952-81	3374	139	0.041
1982-7	1458	32	0.021

Notes to Table 9.2.4:
This data is for the Mototi and the Mutambe samples combined.

Marriage rates are calculated by calculating the number of men between 20 and 59 years of age in each year and summing all years in the time period. This is then divided by the number of marriages recorded to those men. Marriage was actually defined as date of birth of first child deemed in wedlock by initiation or completion of bridewealth payments. There were only two infertile women recorded who lived in wedlock, and these were not included in the analysis. Details of the 'marriage rate' analysis can be found in Chapter Seven, Section 7.1.2).

These rates are highly statistically significantly different: χ^2 11.05, 1df, p<0.001.

In addition to the fundamental socio-economic factors that have reduced marriage rates, men have also been discouraged to marry by a decline in fidelity amongst young women, said to have originated during the Independence war (1975-79 in this area). Extra-marital pregnancy has become more common as a result, especially since contraception - except condoms - are difficult to get by the young and unmarried,[55] and abortion is basically illegal (Kulin, 1988:729).[56] 28% of the first births in the area since Independence were illegitimate.[57] Men would often have been forced into marriage in such cases in past years, including through being otherwise threatened with payment of 'damages' that could be so substantial that relatives would press the man to marry in order to get return on the capital. In the early to mid 1980s men have more frequently managed to avoid this, although Government has attempted to apply pressure through 'Maintenance' legislation under which, if they are salaried, they have to support the child financially through payments to the mother until it reaches 18 years.

Increases in illegitimacy are leading to more unmarried mothers (**mvana**) living with their father's lineage, and unable to find men who wish to marry them. This has been having considerable social implications. However, in Mazvihwa, of late, a number of older men have decided to marry these women - at comparatively low bridewealth costs - and there were four such marriages in my small sample in 1987-8 alone. The eventual marriage of these women, together with marriages of the new cohort of women currently in (or recently out of) education, will presumably soon return the marriage rate to that of the pre-Independence period, though maintaining a depressant effect on fertility.

It is unfortunate that I have no data on the changing ages of women at first birth. However, the age-specific fertility data can be compared with that of the 1969 and 1982 censuses (Table 9.2.5). These data suggest - but the evidence is weak given the small sample size - that women are now starting to give birth later than they did before and just after Independence (that is if the national figures are considered representative of Mazvihwa at this earlier time interval). The effect is particularly marked in the twenty to twenty four year olds, who have on average just 0.5 children in 1987, whereas the figures had been 1.5-1.7 in 1982/1969.[58] This result well illustrates the impact of low marriage rates in recent years. Women now aged over 25 years - who had been over 18 at independence - appear to show broadly similar patterns to 1982, although their fertility is a little lower than that in 1969. This later start to reproductive life in the women under 25 years would be carried over into completed fertility even if there was no contraceptive extension and/or other motives to reduce fertility in later life, perhaps being sufficient to reduce completed fertility by around one birth.[59]

Table 9.2.5 Mean Numbers of Children Ever Born by Age of Woman Evidence for Age-Specific Declines in Fertility Since Independence

	Mazvihwa Sample 1987	1982 Census	1969 Census
10-14	0	0.001	-
15-19	0.3	0.228	0.32
20-24	0.5	1.466	1.737
25-29	3.1	3.065	3.372
30-34	4.4	4.653	4.854

Notes to Table 9.2.5:
The 1969 and 1982 census data are from C.S.O. (1985:148)

The Mazvihwa data are derived from Chapter Seven, Table 7.1.4.1. Mutambe data are excluded as for this sample there is not an accurate denominator for women under 25 years old.

According to Fraser Ross (1955:70) in a survey in 1954 at Harari Hospital in the capital, the modal age for primigravidae was eighteen years, for the second birth, twenty years, and third birth twenty-two to twenty-five years and fourth birth twenty-six years. Although he does not give the mean ages of these births, or birth rates by age categories (and his ages may be biased down by inclusion of only women who knew their ages), it would seem that the Mazvihwa sample represents a marked reduction from this.

Conclusions to Section 9.2

Independence has been associated with a transformation in fertility in several ways. Firstly, there has been a sharp fall in the marriage rate, which is partly related to school attendance and hence desire for later marriage amongst young women. This has been tied to reducing age-specific fertility in the cohort of young women growing up since Independence. Secondly, inflating cash requirements for raising children in the new economy and society (in which the rural areas are more tightly integrated into the national system), are leading to reductions in desired family size. This change only feeds into an existing and long-standing tension in this society in which women have been struggling for paternal agreement to reduced fertility. Improvements in female autonomy, a greater acceptance by men of the need for smaller families, and the availability of contraception, are all now meaning that birthrates for women beyond the generally desired family size of five or so births are decreasing markedly. Contraception is also being used to improve the security of birth spacing, replacing *coitus interruptus*. Though this is important to people it has comparatively little effect on birth intervals of low birth order. The combined effect of these changes, if they persist, will be to lead to a significant slowing of the population growth rate in this area, despite the near halving of infant mortality (Section 9.1).

9.3 Historically Changing Seasonal and Inter-Annual Welfare Dynamics

Introduction

This section briefly reconstructs the changes in seasonal and inter-annual dynamics likely to have occurred during the historical period. These are addressed in the light of changes detailed elsewhere in the ecology of the production system (Chapter Three, Appendix Two), and in hunting, fishing and gathering (Appendix One), working on the principles established for nutrition, health and mortality in current populations (Chapters Five, Six and Seven).

Effects of Migration between Zones

In this region of Zimbabwe, nineteenth century population was restricted to small patches of sandveld with defensive kopjes. Between colonisation and around 1920, there was much dispersal of population, but it was still restricted to areas of sandveld soils, except that several populations judiciously settled along the sandveld-clayveld boundary (and were the origin of the 'Boundary Population' studied in this thesis). From the 1920s there was then an expansion of settlement into the clayveld ecological zone, so that by the 1940s the population was distributed at approximately equal density between zones. The reasons for this (Chapter Three; Appendix Two) are not relevant here, but only the likely consequences for seasonal and inter-annual welfare stress.

It is first worth examining the movement of sandveld families to the sandveld-clayveld boundary, because this was clearly largely a result of a conscious desire to minimise seasonal and inter-annual stresses by making available the resources of both zones. Whilst populations clearly have a number of material objectives in addition to minimising seasonal and inter-annual variations (eg. they might also try to maximise productivity), this well illustrates the central importance of the phenomena under study in this thesis.

A shift of part of the population from sandveld to clayveld will have meant a change in seasonal stress from the wet season to the dry season for that population sector, and also a growing vulnerability to low rainfall years. It should be stressed that in this section I am discussing only the broad ecological determinants of that vulnerability, because specific aspects of the ecology of production also play a role, quite apart from wider economic and social changes (see below).

Changes in the Agricultural System

Sandveld agriculture has broadly changed from a focus on wetland dambos to a system mainly dependent upon topland, but combined with dambo agriculture. The effect of this on inter-annual variation in yields has been to increase variability with rainfall; though of course sandveld yields remain fairly stable relative to clayveld. Indeed it is clear that one of the reasons for declines in wetland use on sandveld was a growing economic security that meant that farmers could accept higher variability in agricultural production (Appendix Two). With the settlement of clayveld, the initial focus was on riverine wetlands. However, as in sandveld, pressures of growing population and the banning of wetland farming by the Government, meant that dryland production quickly became dominant. This will have meant that yields have become more variable, becoming even lower in droughts, and higher in high rainfall years.

A shift away from wetland farming has probably also had impacts on welfare seasonality. Wetland agriculture provides crops and vegetables both in the dry season, and, it can be noted, during the early rainy season as a result of early (dry season) planting. However, the agricultural labour required during the dry season for this wetland agriculture may well act to counter these effects. Overall the result of the reduced importance of wetland farming will probably be enhanced dry season stress in clayveld, at least in nutritional terms. In sandveld it is more difficult to predict the effect of reducing wetland agriculture. On the one hand, wetland agriculture contributes to the high level of welfare stress in the wet season, especially through disease environment. On the other, wetland contributes to the privileged situation in the dry season. It is possible, therefore, that a declining importance of wetland may be reducing the degree of seasonality in nutrition and health.

Changing Importance of Hunting, Fishing and Gathering

Dramatic changes have occurred in the hunting, fishing and gathering resource in Mazvihwa (Appendix One), and these have presumably affected seasonal and inter-annual welfare vulnerability to nutritional stress. In general the decline in fish and game meat availability in the dry season, together with some decrease in fruit supply, may all contribute to increasing dry season stress in clayveld (and decreasing dry season privilege in sandveld). Availability of green vegetables during the rains has changed greatly in species composition, but not in amount (cf. Appendix One), and presumably this has led to little change in wet season welfare stress.

Since these wild resources have played an important role in drought and famine survival (Appendix One), the decline per capita of a number of species with substantial food value (including larger game, certain fruits, plants with edible roots) would be expected to increase drought food stress.

Changing Regional Economic Integration and Social Relations

This is clearly an enormous topic, that can only be touched on at this point. Firstly, the process of pacification (with the spreading of settlement into different ecological zones), of re-pastoralisation, and of establishing transport networks, all contributed to the strengthening of local and regional trading systems that tended to buffer against seasonal and especially inter-annual variations.[60] Secondly a broad economic trend has occurred toward increasing integration into the national largely non-agricultural economy, though this has not been a smooth and even process, due to the fluctuating fortunes of the national economy, changing ideologies and requirements for African produce and labour, and ecological variations, such as droughts (Palmer, 1977; Ranger, 1985; Holland, 1987; Phimister, 1988). This integration has had complex effects, including reducing the general population's dependence on ecological productivity (and hence protection from seasonal and inter-annual stress). It may also have reduced the strength of economic and political linkages within rural communities that had previously protected the poor from variations in food supply (cf. Watts, 1983), and/or allowed the wealthy to exploit the dependence of the poor on such patronage. Changing lineage and domestic relations should also be reflected in child welfare factors, given the fact that these showed up prominently in contemporary cross-sectional analysis (Chapter Eight).

Conclusion to Section 9.3

Although the material in this section has necessarily been speculative and the discussion brief, it is neverthless clear that seasonality and inter-annual variation in nutritional stress, and, to a lesser extent, morbidity vulnerability, are not pre-determined features of environments, but subject to changing human ecological relations in the area. In Mazvihwa changing patterns of settlement and land-use have not only resulted in different welfare dynamics, but have themselves been caused by changing local strategies to manage and exploit such variations in productivity and stress. A case can be made, however, for a partial shift from managing yield variability to a concern with productivity and sustainability, resulting from increasing integration into the national economy, and population and ecological pressure (see Appendix Two). The impact of Independence (1980) has been to accelerate and intensify these changes, rather than to transform rural production systems in a way that itself liberates people from constraining ecological dynamics. (Indeed the fact that ecological dynamics critically effects welfare is illustrated by the results in this thesis, which because of the timing of field work are mostly derived from the post-Independence period.)

A product of this process has been that the ecological dimension to seasonality and inter-annual variation in stress in the clayveld population has been increased, but, it seems, the opposite trend is occurring within sandveld.

9.4 Conclusion to Chapter Nine

Chapter Nine has both strengthened and undermined the central argument of this thesis concerning the importance of savannah ecological dynamics to understanding welfare of African rural populations. On the one hand, I have been able to show how relatively minor social changes (female educational status and possibly autonomy), combined with superficial technical health measures (curative and antenatal services, immunization, and drought/supplementary feeding), were nevertheless capable of transforming child survival, probably improving nutrition, and providing a context for curbing fertility. On the other, I also leave the debate with a reminder that even in the context of such modernisation and with other quite dramatic human ecological changes (that alter seasonal and inter-annual patterns of vulnerability), the population is never able to actually escape ecological dynamics as underlying determinants to welfare in rural societies. This returns us to the conclusions from Chapter Eight that even where birthweight and nutritional status are markedly different between economic categories in the population of an ecological zone, the seasonal and inter-annual dynamics of these variables cannot be shown to vary significantly between population sectors.

CHAPTER TEN: CONCLUSIONS

Introduction

In this chapter I review the thrust of this thesis and the principal conclusions drawn. First I make the case for my central contention that an ecologically and anthropologically informed approach is essential for hypothesis formulation, data collection and interpretation of material on population, health and nutrition in African savannahs. Second, I sum up the argument in this thesis concerning the ecological determinants of seasonal and inter-annual stress, interpreting my results within a somewhat wider context. Finally I indicate areas of weakness in the work, and some avenues for further research.

The Argument for an Ecological Approach

The need to understand the 'ecology' behind rural production systems, nutrition and disease, is not a new concept. Indeed it is accepted orthodoxy. The significant departure from established approaches in this thesis is my use of ecology not as a concept or slogan (cf. Ellen, 1982:73, 90-1), but using advances in 'scientific ecology' as an investigative tool, particularly work on the determinants and effects of savannah dynamics. Scientific ecology in Africa has been developed largely as the study of game parks, though the theories I use here are currently being articulated as informing the management of occupied savannahs, deemed by ecologists as experiencing elevated 'disturbance' and 'stress' as a result (Frost *et al.* 1986). Whilst ecologists have little applied their theoretical advances to empirical fieldwork amongst savannah populations, an entirely divorced 'environmentalist' literature has grown up through studies of rural Africa. This latter literature is not grounded in ecological science or method, offers empirically incorrect statements - and often about irrelevant or non-existent phenomena,[1] and is little divorced from technocratic ideologies about environmental crises that grew up as a function of the colonial encounter.[2] Only work concerned with the more interesting tropical diseases (especially trypanosomiasis, malaria and schistosomiasis) can really be said to escape this damning criticism; at least insofar as the ecology has been applied to population, health and nutrition.

This thesis is structured around a rather limited question arising out of savannah dynamics: patterns of seasonality and inter-annual variability in relation to agro-ecosystem processes. This question basically relates to the stability of production. Wider issues deriving from ecological dynamics, urgently deserving further research, would include resilience and sustainability in relation to production systems and human welfare (cf. Conway, 1986). In this thesis I have basically restricted commentary on these latter issues to Chapter Nine and Appendices One and Two. In those sections I have merely recorded that whilst ecological changes are occurring they are not the driving force behind changing welfare because they are not simplistically 'degradation' (ie. the changes are not necessarily all bad) and, furthermore, people have extremely effective coping mechanisms (cf. Caldwell, 1984; Wilson, 1990a).

Two further points about my use of emerging theory in savannah dynamics need to be made. The first is that I have emphasised the importance of 'disease environment' to welfare, and derived this concept from outside of ecological dynamics, simply using ecological material on the such factors as the extent and nature of wetlands, and the behaviour of dust, to argue for its effects. The second point is that whilst a PhD thesis necessarily takes its theoretical starting point from literature in international journals, my own intellectual 'discovery' of the ecological theories I test actually came from discussions with local people, and only later was 'validated' through library research.[3] Indeed, as I show in Chapter Three, many land-use systems in both pre-colonial and colonial southern Africa were clearly structured precisely on an understanding of these very same ecological principles; and that, in fact, it was the relaying of the 'indigenous' concepts surrounding 'sweet' and 'sour' veld to the scientists via White farmers that sparked off their 'discovery' by ecologists in the 1980s. This derivation of research hypotheses from 'indigenous knowledge', elicited through anthropological field research methods, is a good point to introduce why I argue that biological anthropology, rather than ecology alone, is necessary for research of this kind.

The Argument for Anthropology

The attempt in this study to apply to populations the concepts of savannah dynamics derived from work in areas from which Africans have been removed, does not mean that I assume rural African populations are not involved in social relationships (with eachother, the state, and western financial institutions), and lack the technology to escape superficial 'animal determinism'. Social scientists (particularly historians and social anthropologists) have provided a relatively strong theoretical context for field investigation and interpretation of these dimensions which cannot be ignored. Such an approach combines well, I feel, with an understanding of the ecology of production systems in examining the changing nature and context of the social relations of production and welfare outcomes. The experience of biological anthropology of combining the two kinds of approach and material was drawn upon, together with the access that this gave to the medical and nutritional literature.

Anthropology contributes not only theory but also a method; a more humane but intellectually rigorous approach to studying people through which data can be made more accurate (or at least to have better known problems), and can be more fully understood using the point of view of the people as well as the researcher. Indeed I start off this thesis with a Methods Chapter that articulates how I found it essential to collect data through the local language and from people amongst whom I lived over several years knowing them well as individuals. In distinction from most social anthropologists, and following scattered work elsewhere in Africa (notably by Katherine Hildebrand and other colleagues of Allan Hill), I used selected quantitative human biological measurements to track variables prospectively that would otherwise be impossible to access. When it came to collecting demographic data on events in previous years most of the worst features of single round census-type interview regimes were overcome by the use of intensive interview techniques with known individuals.

Ecological Dynamics and Human Welfare: main conclusions

Whatever the theoretical case for combining scientific ecology with anthropology, the ultimate test of its validity is whether it leads to new hypotheses, new avenues for investigation, and new understandings. I now aim to demonstrate the extent to which this is the case for my own study.

One way of viewing this thesis is the tale of a population that has adopted three strategies with respect to its distribution across an ecological (soil-type) boundary. It is an ecological boundary that few outsiders would notice, or even comprehend if it was pointed out to them. But for the local inhabitants the contrast in soil is marked and fundamental both in terms of the understanding of their own history and ecological strategies in that history, and also as a template on which they tend to think for interpreting ecological processes and their determinants.

One zone is broken granite country with sandy soils whose high infiltration and permeability means that there is groundwater to keep the trees in leaf through much of the dry season, and also natural wetlands providing dry season farming and grazing opportunities. The productivity of the soil is basically nutrient - rather than rainfall - limited, and the environment highly heterogenous due to the effects of both biotic (termites, humans and trees), and abiotic (slope and hydro-geological) factors. All these factors lead to the stabilisation of ecological productivity, seasonally and inter-annually, in relation to rainfall variability. In contrast to this stabilisation in sandveld, the adjacent area of undulating heavy loam/clay soils has little heterogeneity, and productivity is highly dependent upon recent heavy rainfall. In this clayveld site much plant production actually occurs in periods of a few weeks in one year in three. But there are advantages to the clayveld zone: when it is productive it is highly productive. Whilst arable strategies in sandveld are essentially to utilise heterogeneity and make nutrient inputs to achieve steady production, clayveld arable production is necessarily opportunistic, with potentially high returns.

Nineteenth century populations were restricted to the sandveld zone, where highly intensive agriculture was important in natural wetlands largely as a strategy to overcome variability in rainfall and food supply through a high input low output system. Once livestock numbers started to increase and ensure food security, and with the growth of a colonial mining economy that, even if exploitative, was at least little affected by rainfall, people adopted more productive agricultural systems with low production stability. This change was also encouraged by greater independence of producers from chiefly lineage heads, and the introduction of ploughing technology. With the dispersal of populations from their kopje fortresses, much of the sandveld population therefore immediately took the opportunity to settle along the boundary between the sandveld and clayveld zones. Here it appears that they were in an excellent position to minimise seasonal and inter-annual stress through the use of both sandveld and clayveld resources in a complementary manner. With time, however, and partly due to sustainability and population pressure, some of these people based in the boundary zone re-joined others who had never left the sandveld to resume the cultivation of wetlands and neighbouring areas. Others moved in to the 'virgin' clayveld.

Pressure on the resources in this boundary zone, and series of wet years in which clayveld productivity was very high, together with other factors, promoted an expansion into the clayveld zone. Migrants from sandveld were also joined by people being expelled from land for white farmers across southern and western Zimbabwe, and a few retiring African mineworkers from neighbouring countries. These migrants were in a rather different social situation to the people in the old societies of sandveld and boundary. Not tied to patrilineal descent groups by residence, labour mobilisation requirements and land inheritance, and less concerned with chiefdom-centred patronage networks, these immigrants established much more household-centred production systems. Whereas in sandveld and boundary populations the wealthy and the poor currently produce essentially similar amounts of food on average since they 'share' work oxen access, in clayveld there are marked disparities in production. Likewise nutritional status and morbidity in children in wealthy households is only better in clayveld. The more household-based system of the clayveld zone means that access to within-household labour is more important. Perhaps this is why women have on average two more children each in this zone, and why outsider children living in households are of equal nutritional and health status to the 'true' children of the family. In the boundary population it was striking that health and nutritional status were - in contrast - unrelated to wealth but were a function of whether one lived in an appropriately patrilineal relationship to the rest of the people one stayed with.

Sandveld and clayveld populations experience marked seasonal deteriorations in welfare, though at opposite times of the year. In sandveld, which functions similarly to moist savannahs systems elsewhere in the continent, the rainy season is the time of peak welfare stress. In contrast, the clayveld population experiences elevated stress in the dry season (especially hot dry season) in the manner reported for arid savannah systems which it resembles ecologically. The boundary population, however, is fairly well insulated from seasonal stress by both their ecological position, and the fact that they have been historically more important and have relatively good access to remittance and wage income, Whilst some strategies are used to minimise the effects of seasonal stress in sandveld and clayveld, it appears that the costs of, and constraints to, ameliorating seasonal stress are too great for the benefits, and people are obliged to simply tolerate it.

Greater efforts are made by the populations to minimise inter-annual stress, especially where runs of dry or wet years are involved. Droughts stress the clayveld populations but lead to improvements in welfare in the sandveld. (This contrast appears surprising, but there is some justification for it in other little known literature on moist savannahs.) These strategies include various types of migration and exchange between the ecological zones which leads to marked cycles in marriage rates and population structure through time, and at opposite times between the zones; fertility rates per woman, are apparently unaffected, however. Nevertheless ameliorative strategies to minimise such stresses (especially in food supply) are insufficient to prevent decline in birthweight, lower child anthropometric status and increases in morbidity in only the clayveld zone during drought (with possible improvements in drought in sandveld), and infant mortality rate rising during the wet years in sandveld, but dry years in clayveld. This suggests that ecological processes have a stabilising impact upon population dynamics, though, of course, the magnitude of the effects is insufficient to act in a strictly population-regulatory (Malthusian) manner.

The relationships between ecological dynamics and welfare, and between socio-economic differentiation and welfare, have been changing through time. On the one hand patterns of settlement and resource use, and the nature of social relations, have changed historically, under the influence of changing political economy and local initiative. In parallel to this other processes are leading to underlying changes in levels of fertility and mortality. These have been most marked since Independence (1980), and investigation of these demonstrates that changes in medical services (curative services and contraceptive extension) and maternal education (self-confidence and/or modernisation) are principally responsible. It is only these latter processes, driven from outside of the area, that appear to have effects that are divorced from factors of ecological dynamics.

Without the directions from theoretical ecology and the desire to discuss and generate an ecological hypothesis with local people, I could have reached entirely erroneous conclusions about the impact of environment, seasonality, inter-annual rainfall variability and socio-economic differentiation on child welfare. Apart from ideas derived from the explicit ecological argument there was no reason to undertake a disaggregated analysis that looked at ecological zones separately; no such analysis had previously been considered necessary for a human population established across such a soil type contrast. Therefore it is indeed a sobering thought that if I had not analysed the populations in the two zones separately I would have found no seasonality in nutritional status and morbidity (except diarrhoea), and virtually no inter-annual variation in population, health or nutrition. Likewise, because of the superficially opposite effects of wealth on welfare in the ecological zones, there would have been little relationship between socio-economic variables and nutrition and morbidity. Only mortality in relation to wealth and education would have emerged as a finding; and the changing fertility and mortality since Independence would presumably have been interpreted as showing that it was not ecological factors but national political economy that determine welfare - indicative of how wrong can be conclusions drawn from superficial analysis. It should be noted that since this is the first African study to look systematically at the effect of local ecological variation on the dynamics of welfare and differentiation, the general significance of such factors remains unknown. Similarly there may still be other heterogeneity in southern Zimbabwe, either lying hidden in my existing data, or amongst other populations in the region. It is salutary that the enormous variations reported in this thesis occur within a distance of just thirty kilometres. Scale and heterogeneity should be key issues in human ecological research upon welfare.

Cautions and Caveats

This thesis is a field investigation of a small sample in a dry, fairly isolated area of southern Zimbabwe, but its argument is directed to broader issues concerning the relationships between savannah ecological processes and population, health and nutrition in savannah peoples. It is therefore open to criticism on two particular counts. The first is that the essence of case studies is that they inevitably reveal most about local factors - or peculiarities - and contribute least conclusively concerning general principles. In defence I would argue that though I have only established that ecological dynamics are key determinants of welfare stress in my single case study, this still adequately supports my thesis that such a theoretical approach is an important but entirely neglected area of research. But I think that my thesis has established more than this. The critical reanalysis of material in the literature on savannah Africa I have undertaken in this thesis does lend considerable support to the notion that welfare dynamics regimes vary with underlying ecological factors. However, it must neverthless be stressed that this thesis is as much a call for ecologically informed fieldwork on population, health and nutrition, as it is an attempt to resolve the actual relationships involved. Furthermore, my basic hypotheses are wide open for further testing.

The second major caveat is that data quality (sample size, measurement accuracy, length of prospective monitoring), and ideosyncracy of analysis, are inevitably problems in field studies of lone doctoral students. To help the reader I have tried to be as explicit as possible about methods of analysis and argument, and to note problems of data quality and size. In conclusion, however, certain limitations should be stressed again. The sample monitored - around 700 individuals - was too small to sustain some of the analyses satisfactorily, though nearly all of the results were statistically significant. In particular it was too small and wealth-biased in sandveld, and mostly started too late to get adequate prospective data for this zone. This limits comparative analysis to combinations of the limited data with material from other sandveld populations and/or with the boundary population. Prospective monitoring over two years was not long enough to collect sufficient data on morbidity and nutritional status to examine adequately seasonal - let alone inter-annual - variation. Crop production data (three years) is more adequate, but demographic data had to be obtained retrospectively, and the time period for which it is analysed is required to be largely different from the contemporary work with the other variables. Although major new studies accurately monitoring these variables in a large population over many years are perhaps unlikely, there may well be some research mileage in re-analysing existing data for populations such as those studied by the MRC supported Dunn Nutrition Unit in the Gambia.

Future Research Directions and Prospectus

In terms of avenues for further research and investigation I would prefer to comment on research strategies rather than questions. I would hope that this thesis is a vindication of the necessity to ground research in long term rural residence, participatory relationships with local people, and the collection of a range of types of human biological and anthropological data. Such data can be made to become meaningful if framed within ecologically inspired hypotheses, insofar as these relate to local production systems and disease environments. Turning to the issue of the relationship between socio-economic differentiation and welfare, being 'wealthy' and 'poor', and engaging and not engaging in strong inter-household relationships should be seen as <u>strategies</u>, rather than as simply the result of success and failure of people all trying to live in the single 'best' way and be as 'wealthy' as possible. Such strategies need to be investigated from the point of view of different actors (by gender, age and status) operating within historically changing contexts, and so can only be investigated through anthropological techniques.

The strength of the survival revolution and start of demographic transition in Zimbabwe beg many further questions about the biological relationships between welfare outcomes and factors such as wealth, modernity, domestic organisation, gender relations, maternal education, and food availability.

Understanding these will clearly require a combination of micro-level analysis with carefully disaggregated and 'controlled' statistical work. This thesis draws attention to the fact that studies of rapid changes in welfare variables need to be founded upon detailed analysis of local social and ecological relationships in interaction with national political economy.

In a continent plunged into political-economic as well as ecological turmoil,[4] a call for such detailed long term field studies may appear curious. But since the macro-political and economic solutions are unlikely to be addressed, and the well-being of rural Africans will largely reflect their own capacities to respond, these local dynamics of survival strategies, environment and social process need documenting, comprehending, and possibly even support.